Main challenges of a Circular Economy approach for the Cement and Building Materials Industry in Portugal and for Secil

Consulting Lab Project

Under the supervision of Professor Constança Casquinho

Alexandra Moniz nº 2977
Miguel Fontoura nº 2505
Pedro Pinto Gomes nº 2761

NOVA School of Business & Economics

Shaping powerful minds

January 6th, 2017

Glossary

Clinker	A dark grey incombustible material made by heating ground limestone, clay and other minerals, which is used to produce cement
Cement	A building material made by grinding clinker and gypsum to a fine powder that can be used as an ingredient for mortar or concrete
Concrete	A building material consisting of cement as the binding agent, aggregates, water and admixtures
Aggregates	Mineral materials sourced at quarries that are used in making concrete, asphalt and mortar, such as sand, gravel and crushed stone
Bitumen	A black viscous mixture of hydrocarbons obtained naturally or as a residue from petroleum distillation
Mortar	A mixture of sand, a binder such as cement or lime, and water and is applied as a paste which then sets hard
Fly ash (PFA)	Pulverized Fly Ash consists in a by-product of combusting coal in thermal power stations
Slag (GBFS)	Ground Granulated Blast-Furnace Slag consists in a waste product from steel production by basic oxygen furnace technology
Pozzolana	A type of volcanic ash of siliceous or silico-aluminous composition that can be used in the production of mortar or cement
Landfill	A carefully designed structure built into or on top of the ground in which waste materials are isolated from the surrounding environment

Agenda

1. Introduction and Project Background
2. Industry and Company Overview
3. Impact of the Industry to the Environment
4. Sustainability and Circular Economy
5. Key Initiatives and Priorities for Secil

NOVA School of Business & Economics

Shaping powerful minds

The Team and Project Advisors

The Team

Alexandra Moniz

Pedro Pinto Gomes

Miguel Fontoura

Project Advisors

Fernando Lopes – Business Development Manager

Prof. Constança Casquinho

Context and Limitations of the project

- This was not a typical academic research project but rather a **consulting project requested by Secil to Nova SBE** in order to address a specific issue with significant potential impact to the Client's industry and business

- This document aims to analyze the potential impact of the challenges emerging from the concept of **circular economy** to the **cement and building materials industry** and also present the main priorities for the company

- This concept is still at an **early stage** with the industry trying to identify the most significant trends and anticipate the possible changes of the regulation within a context of high uncertainty

- The **Field Lab work** project was done over a period of **10 weeks at Secil** and comprised Team work with a problem solving format or research approach as well as several expert interviews both to provide input and also to validate Team hypothesis

Issues to Address and main Project Goals

Problem Statement:

- The growing environmental concern led to several global initiatives that aim to ensure economic sustainability, the optimization and recycling of the existing resources and, within this front, emerged more recently also the circular economy concept.
- These initiatives have been translating into new regulation and recommendations that vary across industry and, in some cases, also across regions. The industry of building materials is one of the largest consumers of natural resources (both raw materials and fuels) and has also a significant production of end product residues. Naturally, this is already one of the most regulated sectors, but its players, aware of the impact of the industry have also proactively invested in improving its efficiency and reducing its impact on the environment.
- Despite these improvements, changing consumption trends and increasing regulation will bring additional and significant challenges for the industry as a whole and for the sustainability of its players.

In this context, the Project with Nova SBE had 3 main goals:

1. **To understand the main regulatory trends that can impact the industry of the building materials** – this should cover not only the possible changes to the existing EU and national laws and directives but also new developments and its potential impact for Secil.

2. **Evaluate the initiatives and measures that have already been done by the industry and by Secil –** this should be the base to access the state of readiness to deal with the upcoming challenges.

3. **Identify the most relevant issues and opportunities for Secil and the possible actions the company should take to adapt its processes and products** – this should consider the relevant product development of the main players and new research in the pipeline of being tested and how it could be adopted by Secil.

Methodology

The methodology used in this Project consisted of 3 main stages

Methodology

1 External and internal analysis

- Basic industry and company overview
- Analysis of international benchmarks, best practices and trends in the industry worldwide
- Revision of the relevant industry environmental regulation
- Identification of the main concepts and frameworks of the circular economy

2 Identification of key environmental initiatives

- Internal field interviews with Secil managers to identify the key regulation risks for Secil and understand the main environmental initiatives from Secil
- Analysis of the potential impact of the initiatives identified
- Interviews with external experts and Secil managers to validate the Team analysis and hypothesis

3 Selection of the most relevant initiatives and final recommendations

- Analysis and structure of the implications and requirements for the most relevant initiatives
- Participation in the National Innovation Forum (COTEC, this year under the main topic of circular economy) with some help provided to the Client interventions
- Elaboration of final Team recommendations

Executive Summary

- The Cement and Building Materials industries are among the main consumers of natural resources and its production process release significant amounts of residues and emissions and thus have always been heavy regulated.
- Growing environmental and sustainability concern is leading towards even more regulation and new limitations on the industry impact on the environment.
- The companies cope with these challenges by researching new products and developing new, more efficient technologies and production processes that are less impactful to the environment.
- The concept of circular economy aims to minimize further the negative environmental externalities, and raises the challenges to the whole value chain and production cycle of the industry.
- Based on the Ellen MacArthur's model, our team developed the "7 R's framework" in order to analyze where can Secil – as a leading cement and construction materials company in Portugal and with sizeable presence in other continents – improve and innovate in the context of circular economy.
- The outcome of this document is a selection of 5 initiatives or potential projects that are not yet explored by Secil and that can deliver a strong impact for the company in the long term.
- Furthermore, the team identified two critical uncertainties, out of the five final initiatives, to further elaborate different scenarios regarding how will these uncertainties develop in the future and, how what are Secil's strategic options regarding the different scenarios

NOVA School of Business & Economics

Shaping powerful minds

1 Introduction and Project Background

2 **Industry and Company Overview**

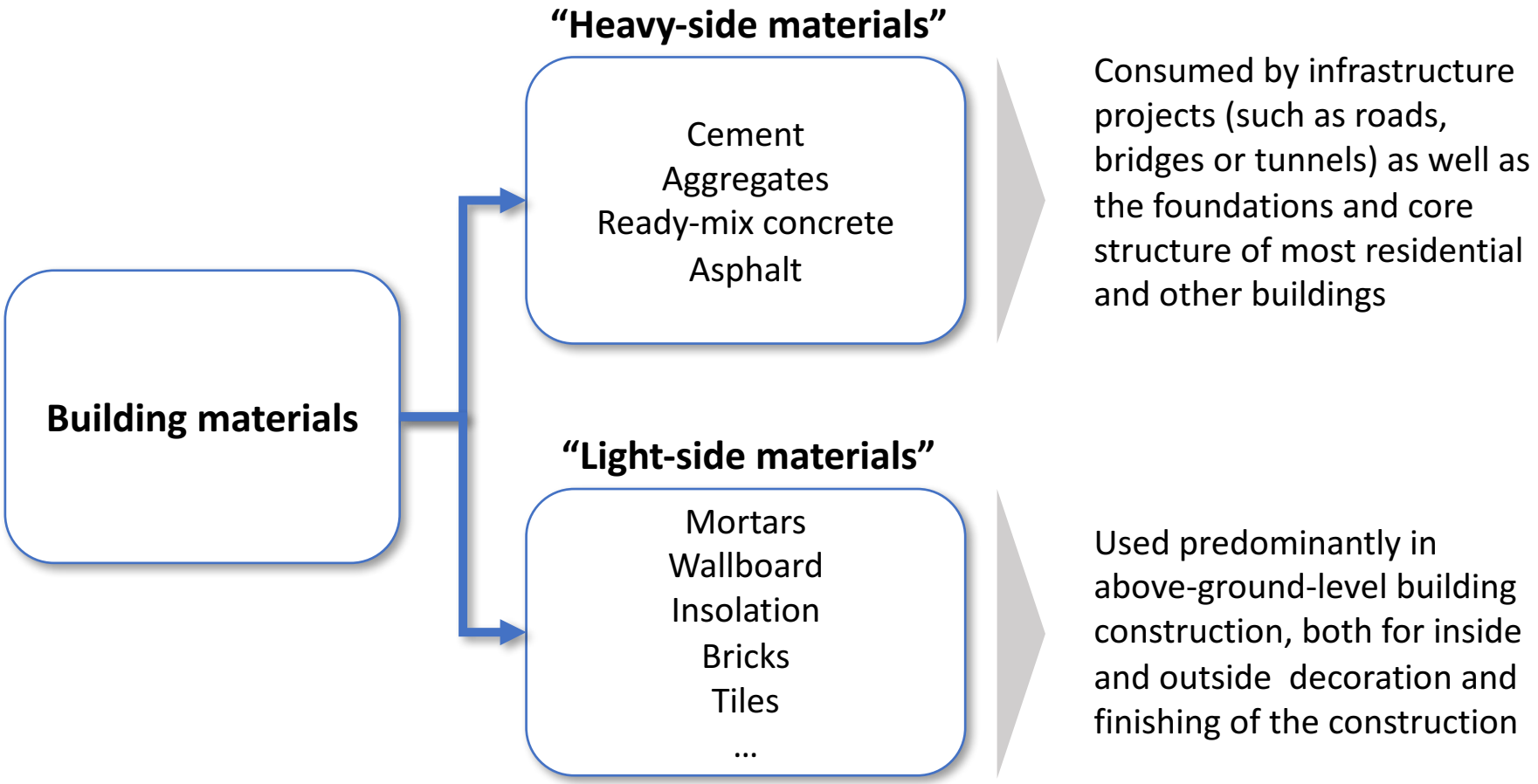
3 Impact of the Industry to the Environment

4 Sustainability and Circular Economy

5 Key Initiatives and Priorities for Secil

Building materials can be divided in two main groups of products according to their function in the construction process

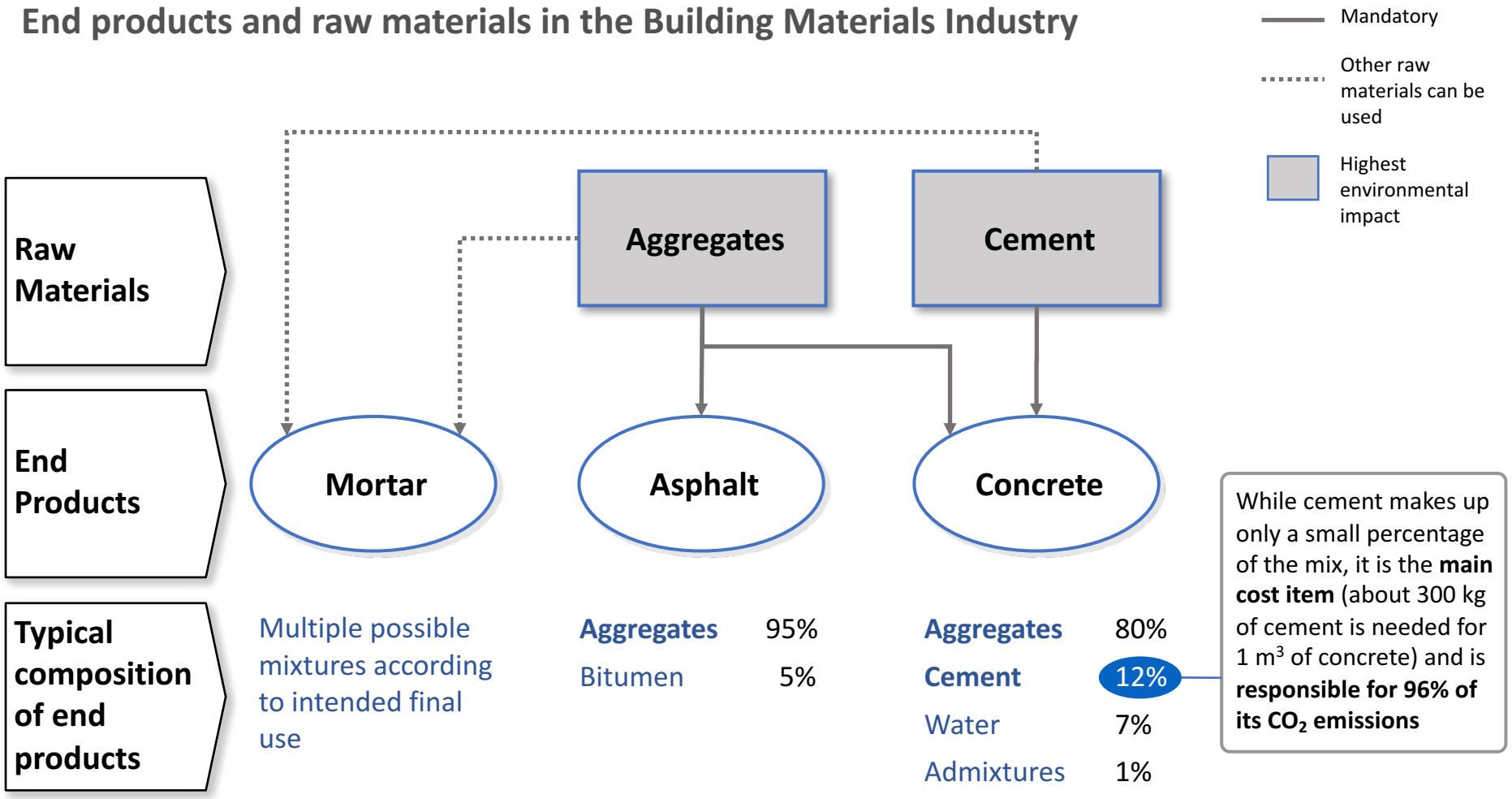
Two main categories of building materials



Source: HSBC

Concrete is the main end product and consumes most of the aggregates and cement, which, as a product has the largest environmental impact

End products and raw materials in the Building Materials Industry

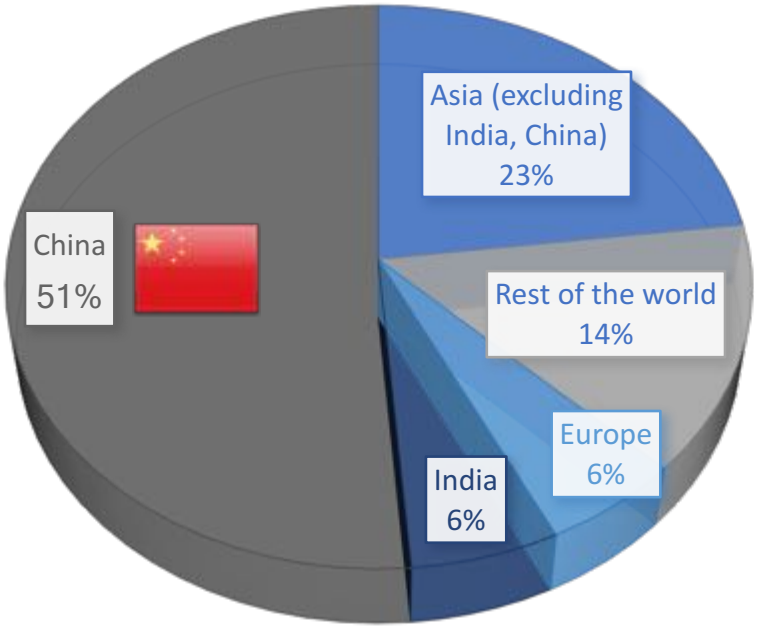


Source: Secil/NovaSBE Team,Ellen MacArthur Foundation

The impact of cement production and consumption in the environment is further enhanced by the fact that most of it happens in less regulated, emerging countries (e.g. China or India)

Global Cement Industry – Key Figures

World cement production in 2015, by region and main countries (% of total)



100% = 4.6 billion metric Tons

Key figures for Cement Worldwide

- **€17.5 B** annual sales
- **4.6 B** metric tons (~600 kgs pc)
- Cement consumption follows **economic development** up to a certain stage, then remains stable
- China alone represents **more than half** of global production and consumption
- Main players are either **large local companies** or belong to a dozen of **multinationals**
- Total thermal energy consumed per year equals to **118 million barrels of oil**

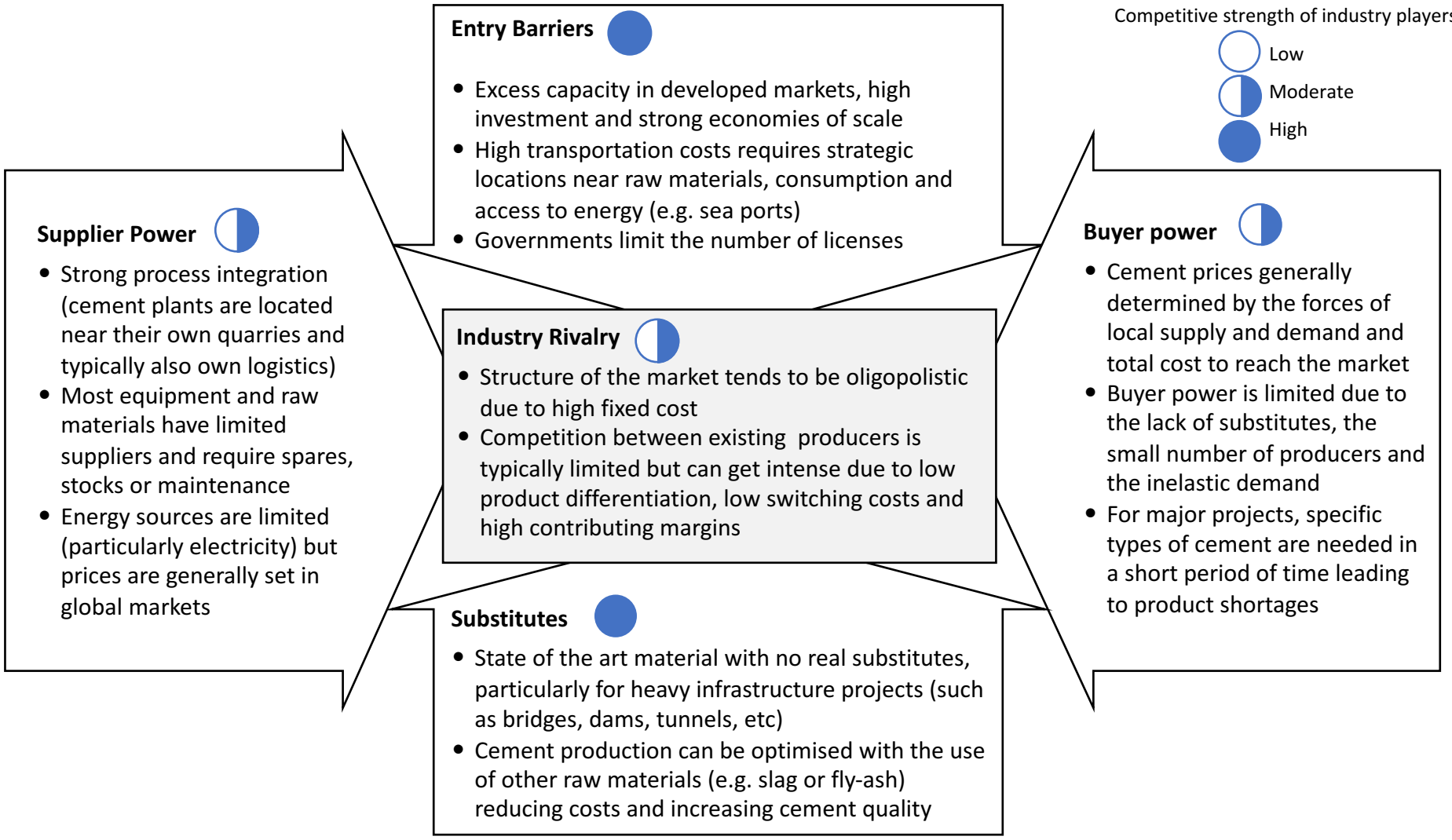
Source: Secil/NovaSBE Team, Cembureau

The Cement Industry requires high investments with long payback periods and has a strong impact on local economies

Characteristics	Implications for the Industry
Homogeneous, standard product	• There are only a few classes of standard cement formulas that most companies can produce • Price is the most important sales parameter next to customer service • Quality premiums exists but are limited for special types of cement or use
Energy intensive process	• 1 cement tonne requires 60 to 130 kg of fuel oil or its equivalent, and 110 kWh of electricity • Additional fuel is spent on distribution logistics (truck, rail, ship, etc.)
Capital intensive	• Cement plants can cost from $150-300 per tonnes of installed annual capacity • Plant upgrades are planned considering the long-term demand/supply and cost evolution • Typical payback period of a cement plant can take up to 10 years
Low-cost and heavy product	• The price of long road transportation may be higher than the cost price • Bulk shipping is a better option than to use trucks to move cargo • In large markets, regional clusters become natural
Critical but mature product	• Clearly linked to state of economic development and the overall GDP growth rate • Growth follows GDP in developing markets and population growth in mature markets • Cement availability is critical for major public infrastructure and development plans
Variable labor intensity	• Automated processes and continuous material handling devices enables a modern plant to work with less than 150 people • In developing countries, processes are still more manual and require more low skilled labor

Source: Cembureau

Most of the Competitive Forces at work in the Cement industry tend to create few, strong local champions or global players



Source: Secil/NovaSBE Team

Secil is a leading player from Portugal with a significant and growing international presence

Company, Mission and Vision

Company

- Secil is a Portuguese based business group, detained and supported by the holding company Semapa, that produces and sells **cement, concrete, aggregates and mortars**
- Secil has its own technical centres focused in the development of new construction materials, process optimization, environmental services and the use of alternative energy sources
- The group currently operates **8 plants in 7 countries**, located in 4 continents with almost 10 million tons of capacity and uses part of it to export for more than 50 countries, namely from Outão/Setúbal
- In 2015, Secil had revenues of **478 million euros**, a 11% increase compared to the previous year, reflecting the start of operation of its new plant in Brazil

Mission

- "We are an international company of cement and building materials, aimed at creating value for the benefit of the company's stakeholders. We utilize resources in a sustainable way, offering high quality and innovative products, through the excellence of our employees and respecting the communities in which we operate."

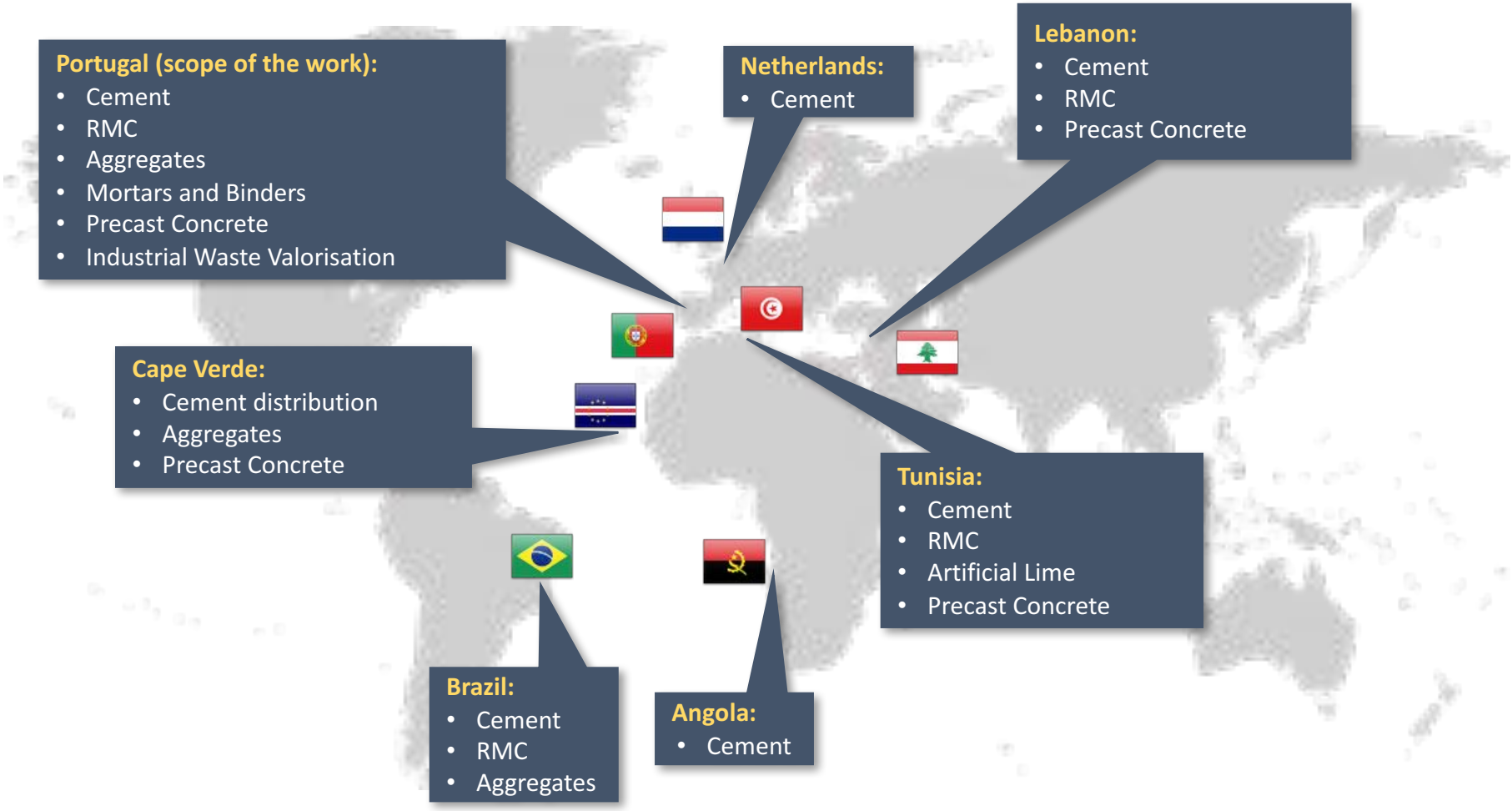
Vision

- "We aim to extend our impact to new geographies and markets, offering sustainable construction products and solutions, creating an environment built to benefit and improve society's quality of life."

Source: Secil-Group Website

Secil has been exploiting international opportunities (plants in emerging countries and terminals in stable markets) to balance its portfolio and benefit from local market conditions

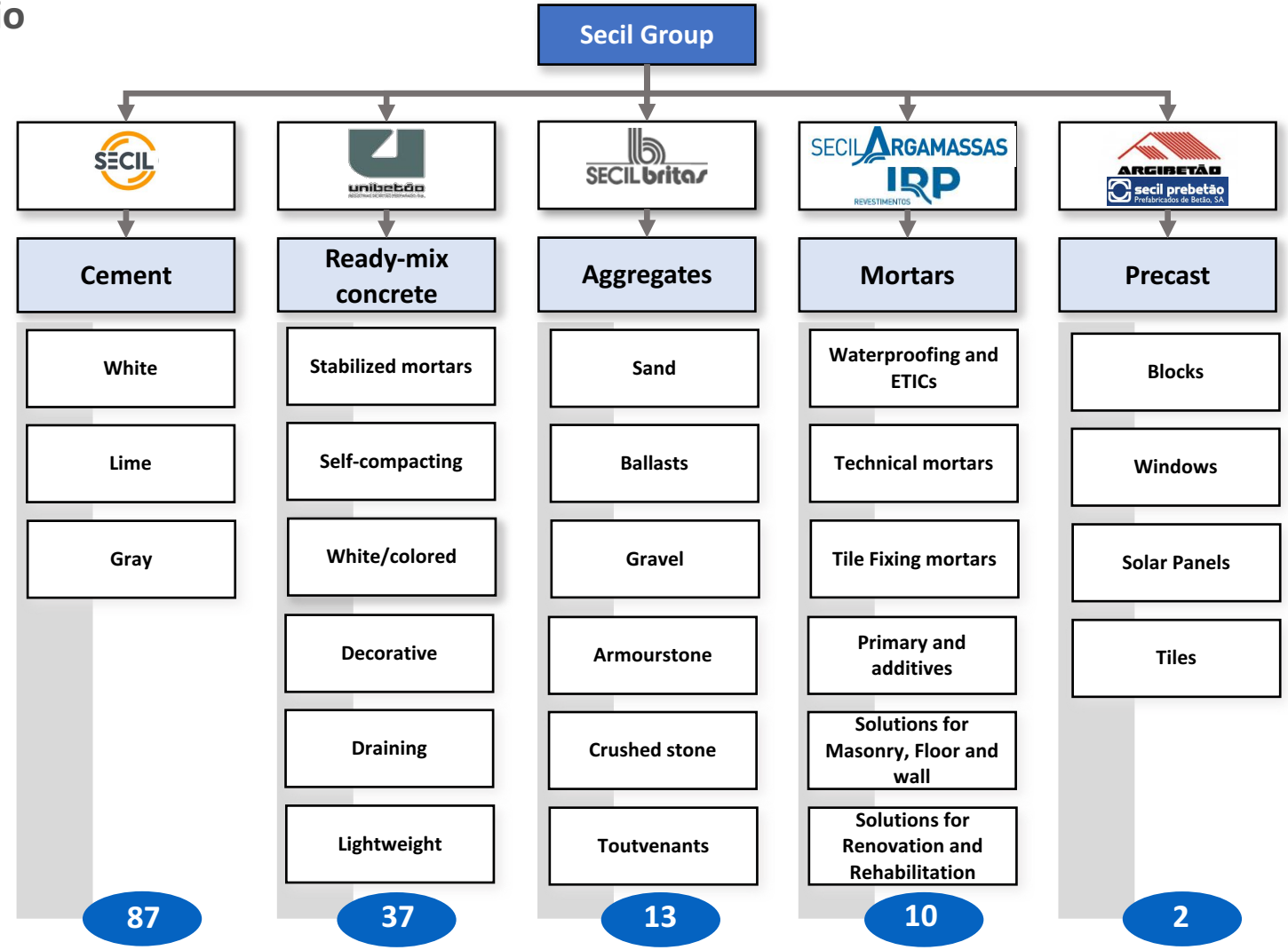
International Presence and Products



Source: Secil/NovaSBE Team

Secil also benefits from having a wide and complementary range of products across the value chain with synergies from vertical integration

Product Portfolio

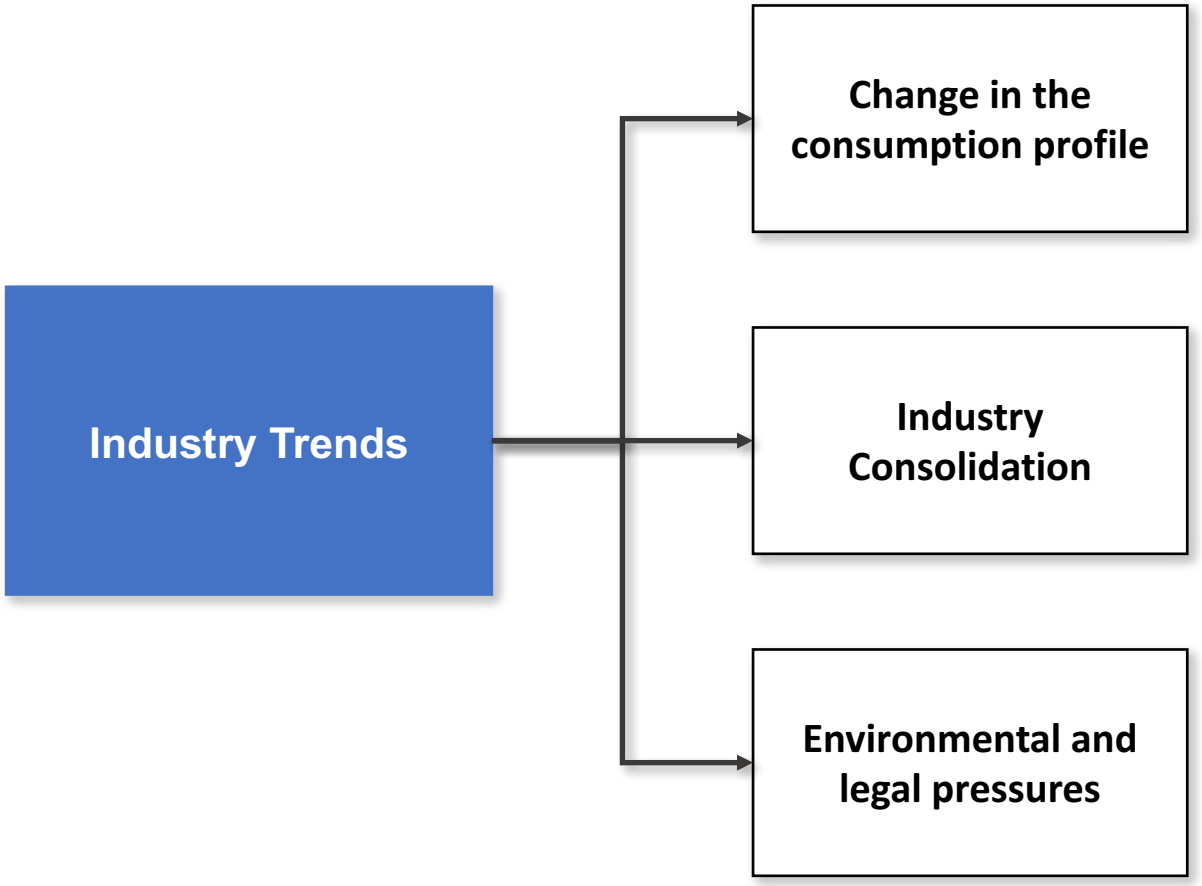


Gross Revenues in Portugal, per segment (€M 2014)

Source: Secil/NovaSBE Team

Three key emerging trends are combined to bring more pressure to most players of the building materials industry

Main trends in the building materials industry



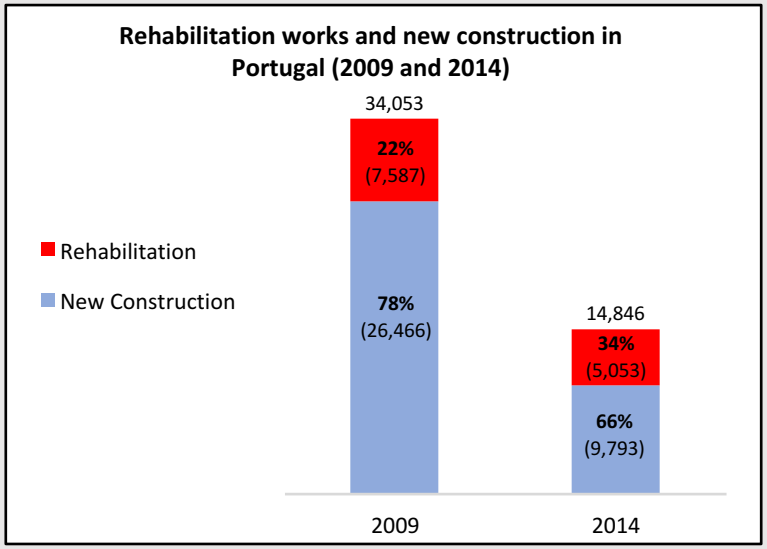
Source: Secil/NovaSBE Team

A higher percentage of rehabilitation constructions is changing the type of materials consumed towards less cement which requires a fast adaptation of the suppliers

Industry Trends

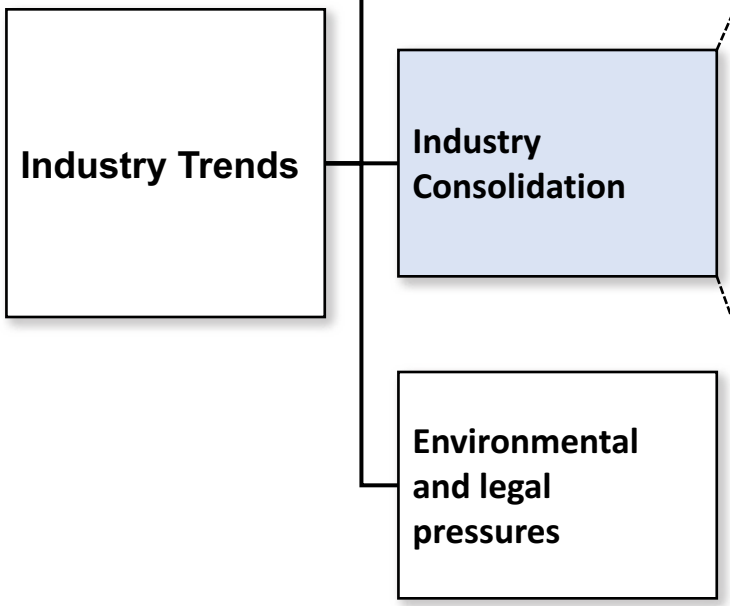
- **Change in the consumption profile**
- **Industry Consolidation**
- **Environmental and legal pressures**

- Total number of constructions declined to **less than half** in just 5 years
- Within this trend, **Rehabilitation** constructions represent now over a third of total constructions
- **Rehabilitation requires a different construction approach**, usually consuming less cement leading to a substitution of cement for other materials such as mortars and plaster



Source: INE

Cement is primarily a local business but global cement players benefit strongly from synergies and roll-out of best practices



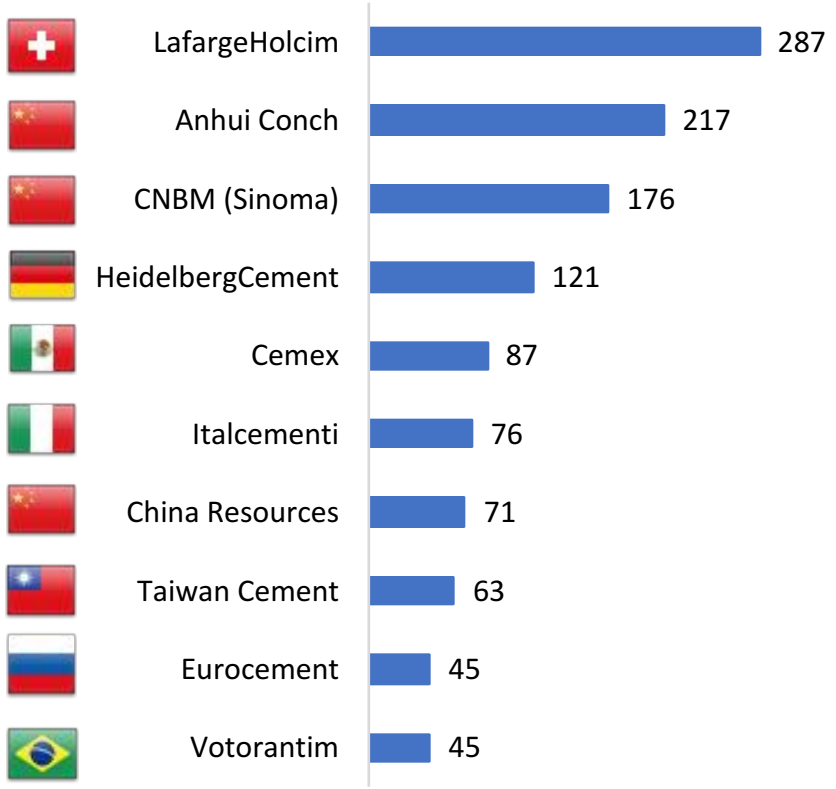
- **Top 15 companies have one-third of global capacity**
- **Increase in M&A between the main players**
  - Lafarge merged with Holcim and the merged entity became the largest company
  - Heidelberg acquired Italcementi
  - Cemex sold assets in the US (to Argos)
  - Most of the divested assets from these transactions were acquired by other regional players (such as CRH, Titan or Cementir) that also broaden its global reach and size
- These mergers reduce the number of relevant cement players globally and **put more pressure on the local players** that need to have superior location, better technology, innovative products or lower production costs to be able to compete effectively with the majors

Source: Global Cement

The top 10 players increased their market share to almost 30% but the fastest growth came from China and other developing countries

Competitor Analysis

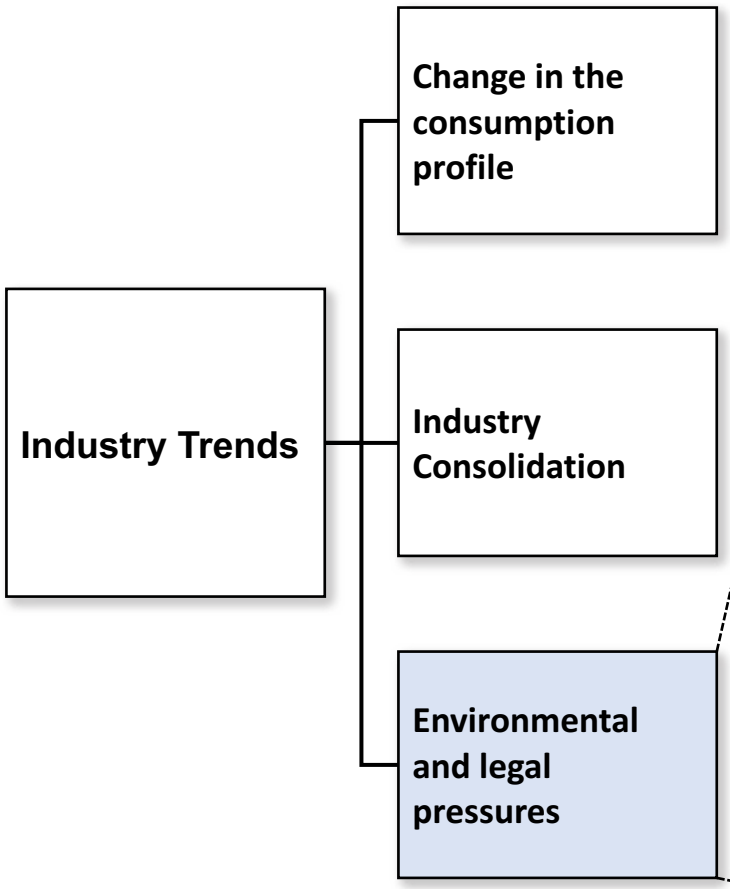
Largest cement companies in the world by production capacity (Million tons, early 2015)



- The top 10 players represent almost **30% of global capacity installed**
- Most of them come from China and other developing countries (BRIC)
- The ranking is changing as most players keep optimizing capital allocations and managing its portfolio with specific asset sales
- Market leaders in large profitable markets (such as Cemex in Mexico, Eurocement in Russia or Votorantim in Brazil) grew in size but not in geographical reach due to its high debt costs

Source: Secil/NovaSBE Team, Global Cement Magazine

The industry is also facing mounting environmental protection regulations, given the impact of the cement production process



- Cement production implies a high environmental impact through **air, water and noise pollution**, but also through the **extraction of natural resources and fuel consumption**
- Strict environmental restrictions have emerged in the context of the **Paris Agreement**
- Companies were pressured to promote a transition towards a more **"green" cement**, which is facilitated by modern technology, use of alternative fuels and other raw materials:
  - **Waste heat recovery systems**, to convert waste heat into electricity
  - Use of **alternative fuels such as biomass**
  - **Alternative raw materials such as fly ash, slag and pozzolana** actually improve cement qualities and reduce its production cost

Source: Secil/NovaSBE Team

The STEEP analysis shows that the pressures on the cement industry come from all external fronts, from economy to regulation or even social and market factors

STEEP[1] Analysis

	Findings
S Social	• Less budget for government spending in infrastructure and social projects • Ongoing urbanization[1] (64% of total population) but at a slower pace • Consumers are more environmental conscious
T Technological	• Smart homes, more durable and energy efficient buildings • New business models (trend toward rent and rehabilitation not new buildings) • New techniques regarding waste recycling/reduction
E Economical	• Economic Uncertainty and stagnant GDP growth • Low interest rates and inflation in some markets • More pressure from banks on high debt companies
E Environmental	• Carbon footprint concerns • Adoption of Alternative Sources of Energy • Natural Resources scarcity
P Political/ Regulatory	• Growing legislation on GHG emissions • Lack of legislation concerning the pricing of raw materials and cost of landfilling does not create an incentive for sustainable production

Source: Secil/NovaSBE

Note 1: Social, Technological, Economical, Environmental and Political

The pressure to reduce the impact of the cement in the environment comes at a time where most companies also face serious challenges in their markets and in industry as a whole

Challenges of the Cement and Building materials industry

Challenges arise from two main types of problems

Industry problems

- Excess capacity installed in most markets
- Changes in the consumption profile
- Reducing volumes in developed markets
- End products with a long life cycle
- Price sensitivity and product substitution
- High cost of debt and fixed cost structure
- High maintenance and upgrade investments required to remain efficient
- Emerging countries have an increasing relevant role in the industry
- Market depends on public investment

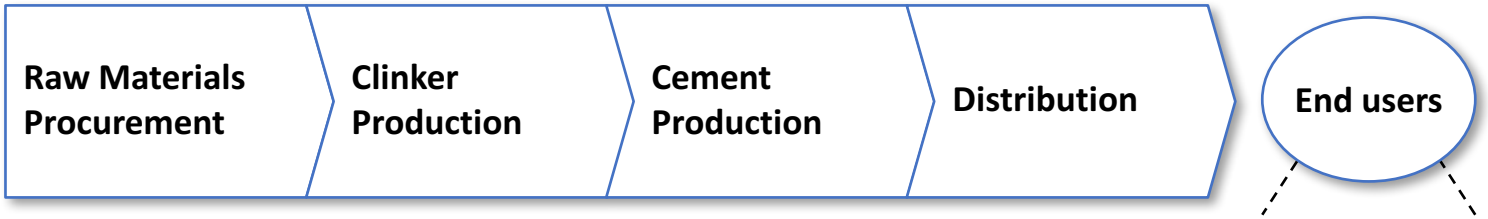
Environment-related problems

- Water and soil pollution
- Air pollution
- Impact on biodiversity and ecosystems
- Resource scarcity

Source: Secil/NovaSBE Team

Cement production has a strong impact on environment with specific issues across its production process

Value chain of cement and key environmental issues

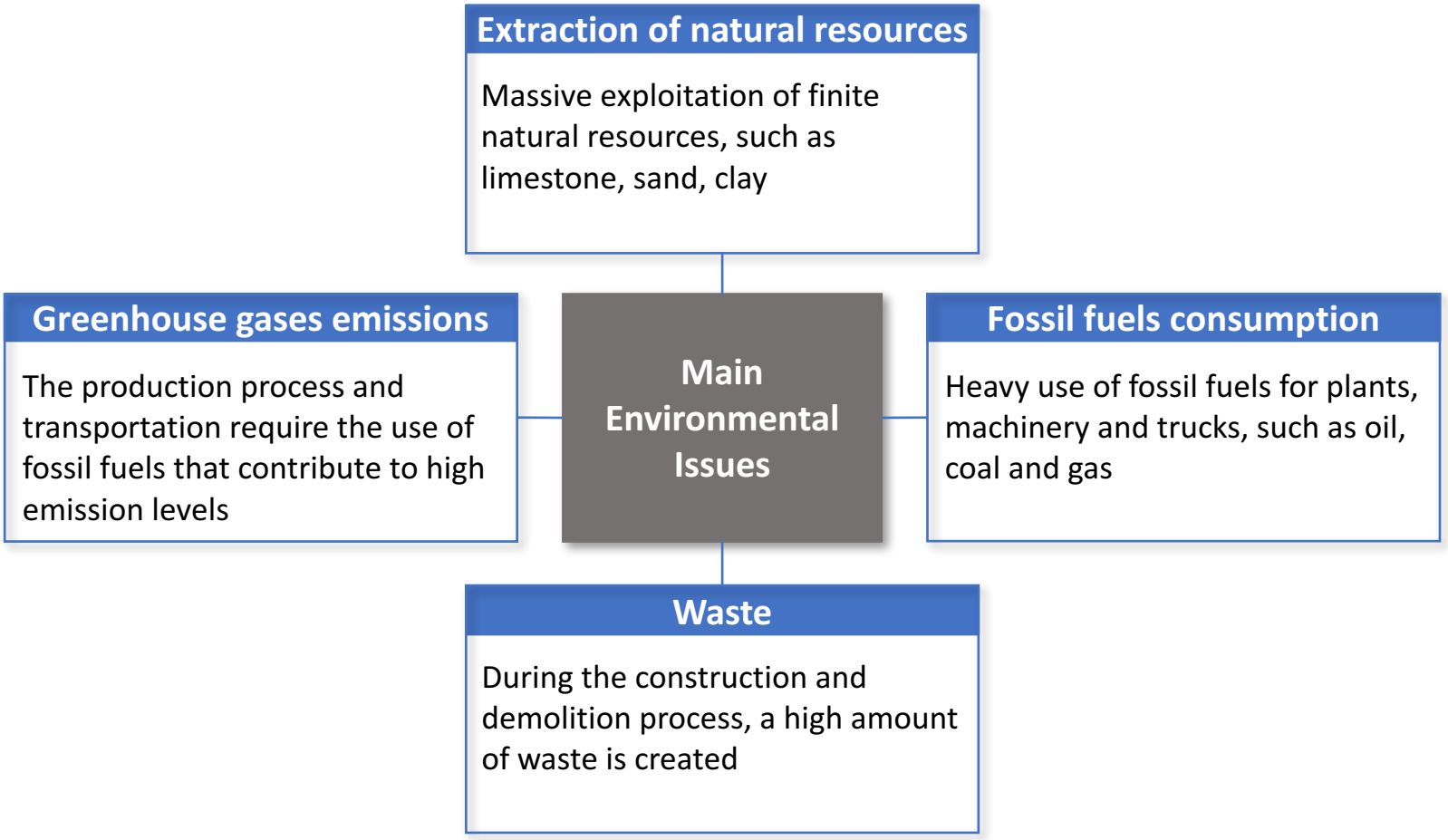


	Raw Materials Procurement	Clinker Production	Cement Production	Distribution	End users
Main steps	• Drilling for limestone, clay and sand • Loading Shovel • Dumping in Trucks • Transporting and dumping in the crusher • Grinding and setting the composition of the mixture	• From the blending silos the raw materials mixture is processed in a rotary kiln • Follows several stages: heating, dehydration, calcification and cooling	• Grinding of the clinker together with a binding regulator (gypsum) and other additives • Storage of cement in bulk or in bags	• Cement can be distributed by train, ship or truck • Bags or bulk	From wholesalers and retail chains (DIY) to large direct contractors
Key Environmental issues	• Natural resources (limestone, sand, clay) consumed • Fossil fuels for transport and extraction	• Fossil Fuels (pet coke, coal) • High electricity consumption in plants • Carbon dioxide (CO_2) emissions • Production waste		• Fossil fuels for transport	• Construction and demolition waste (CDW)

Source: Secil/NovaSBE Team

The impact of the cement and building materials in the environment can be split into 4 main categories

Main environmental issues from the building materials industry



Source: Secil/NovaSBE Team

The cement production process begins with the extraction of finite natural raw materials at quarries

Extraction of natural resources

World cement demand in 2014 per region (million metric tons):

• North America	136
• Western Europe	126
• Asia/Pacific	3158
• Central & South America	153
• Eastern Europe	120
• Africa/Mideast	467
TOTAL	**4160**

The extraction of natural resources will continue to increase since global demand for cement is expected to rise 4.5% until 2019

Worldwide estimated consumption of natural resources for cement/concrete production and usage in construction in 2014 (approximately and in Billion metric tons/year):

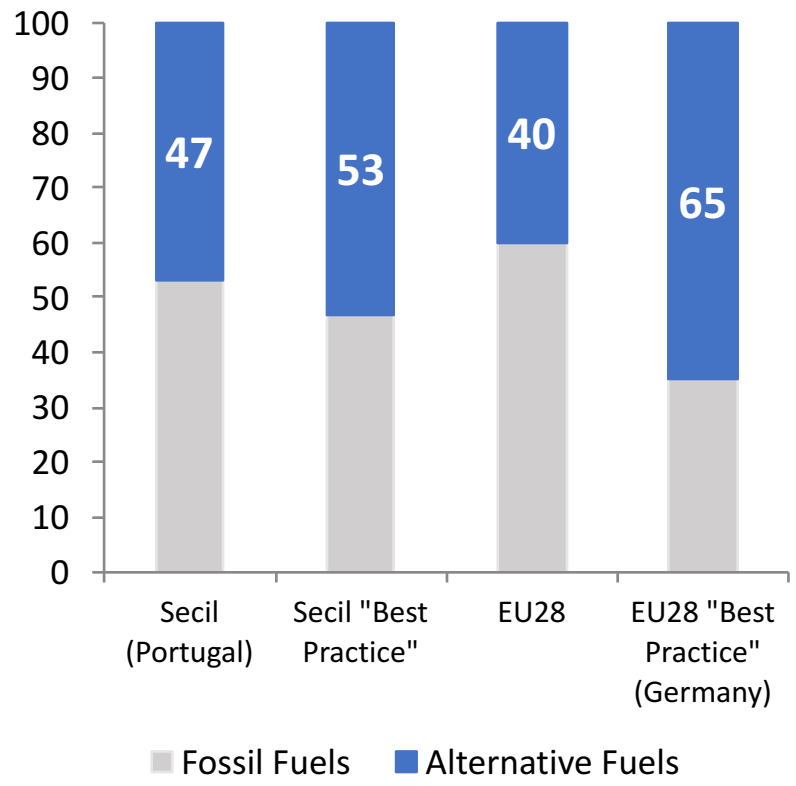
- **5.3 B** t/y of Limestone for cement production
- **43.3 B** t/y of aggregates for concrete and other uses in construction (including both sand and crushed stone)
- **0.4 B** t/y of clay/pozzolana
- **0.2 B** t/y of gypsum
- **Also 0.2 B** t/y of slag and **0.2 B** t/y of fly-ash with a positive impact on the environment (reduces the amount of clinker and limestone needed)
- **15% of all oil consumed**
  (both for production and distribution/transport/logistics)

Source: Secil/NovaSBE Team, The Freedonia Group

Although fossil fuels are still the most used and contribute to the emission of polluting gases, the industry has been investing in alternative fuels for some time with good results

Fossil Fuels Consumption

Main types of fuels used at Secil and in the EU28 (% of total)



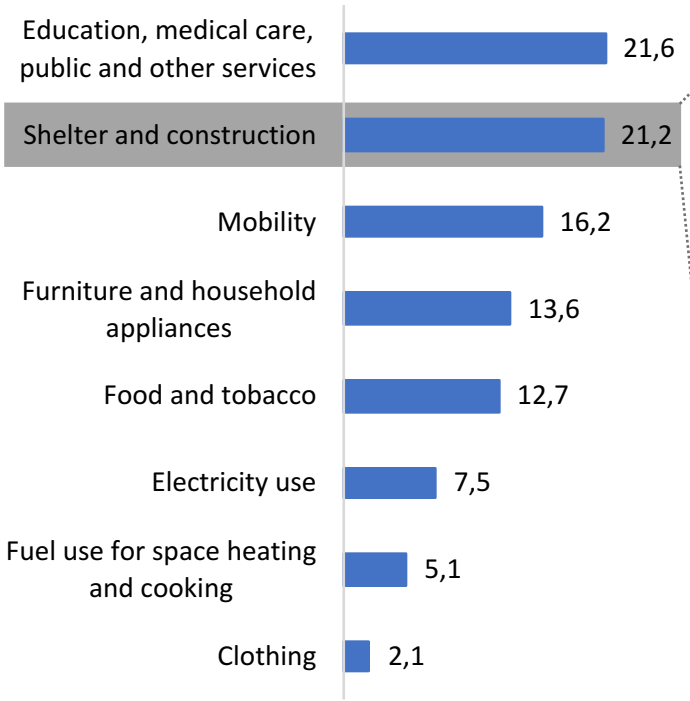
- The cement and building materials industry is heavily dependent on conventional **fossil fuels,** such as **natural gas**, **oil** and **coal,** at all stages of the production process
- Some **alternative fuels** (biomass, used tires, plastic waste, etc) can be used to meet the thermal needs of the production process, thus reducing the use of non-renewable sources and decreasing costs
- When burning alternative fuels, there are two variables to consider: its t**hermal potential** and its own **impact on the environment** as well
- **Fossil fuels are still the best option** because they provide the best balance of thermal potential and cost, despite its negative impact on environment
- Secil has already better/similar levels of alternative fuels as EU28 average but some specific plants in EU are able to use non-fossil fuels at a higher level

Source: Getting the numbers right (GNR) 2012; Secil 2015; CSI 2014

Despite the improvements in its production process, cement and building materials industry are still a key contributor to the global GHG emissions

Greenhouse gases emissions

Main consumption categories and their share in global GHG emissions (% of total)



Main polluting sectors	%
Petroleum, chemicals and non-metallic mineral products	31.7
Electricity, gas and water	27.8
Mining and quarrying	11.2
Electrical, machinery, metals and manufacturing	11

Relevant category

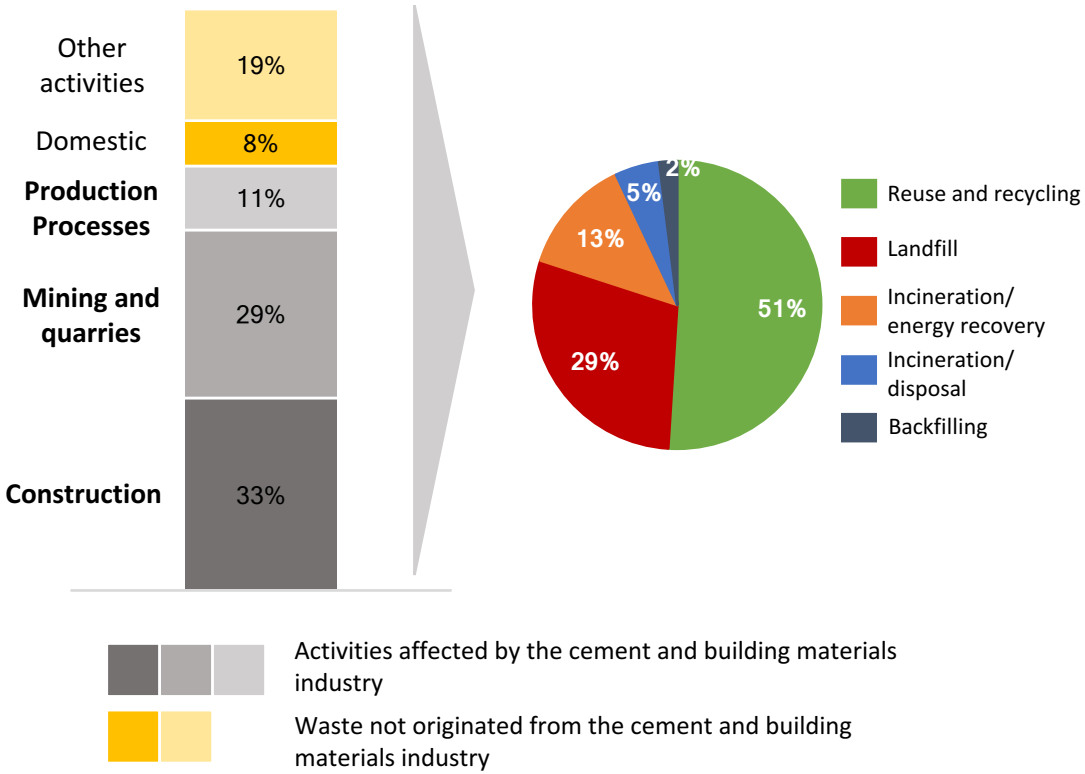
- Globally, cement production alone is responsible for **7% of annual GHG emissions**
- The cement and building materials industry contributes to the emissions of the **second most pollutant consumption category**
- Emissions from cement production come from the use of fuels (around 40% of total emissions) to heat **limestone, clay and sand**; the calcination process (about 50% of total); and the use of electricity and transport of 10% of the total)

Source: Ecofys, WBCSD, The Ellen MacArthur Foundation

The cement and building materials industry also produces a significant part of waste and residues that could (and should) be recovered

Waste

Global waste production by economic activity and type of waste treatment[1] in UE28 (2012, % do total)



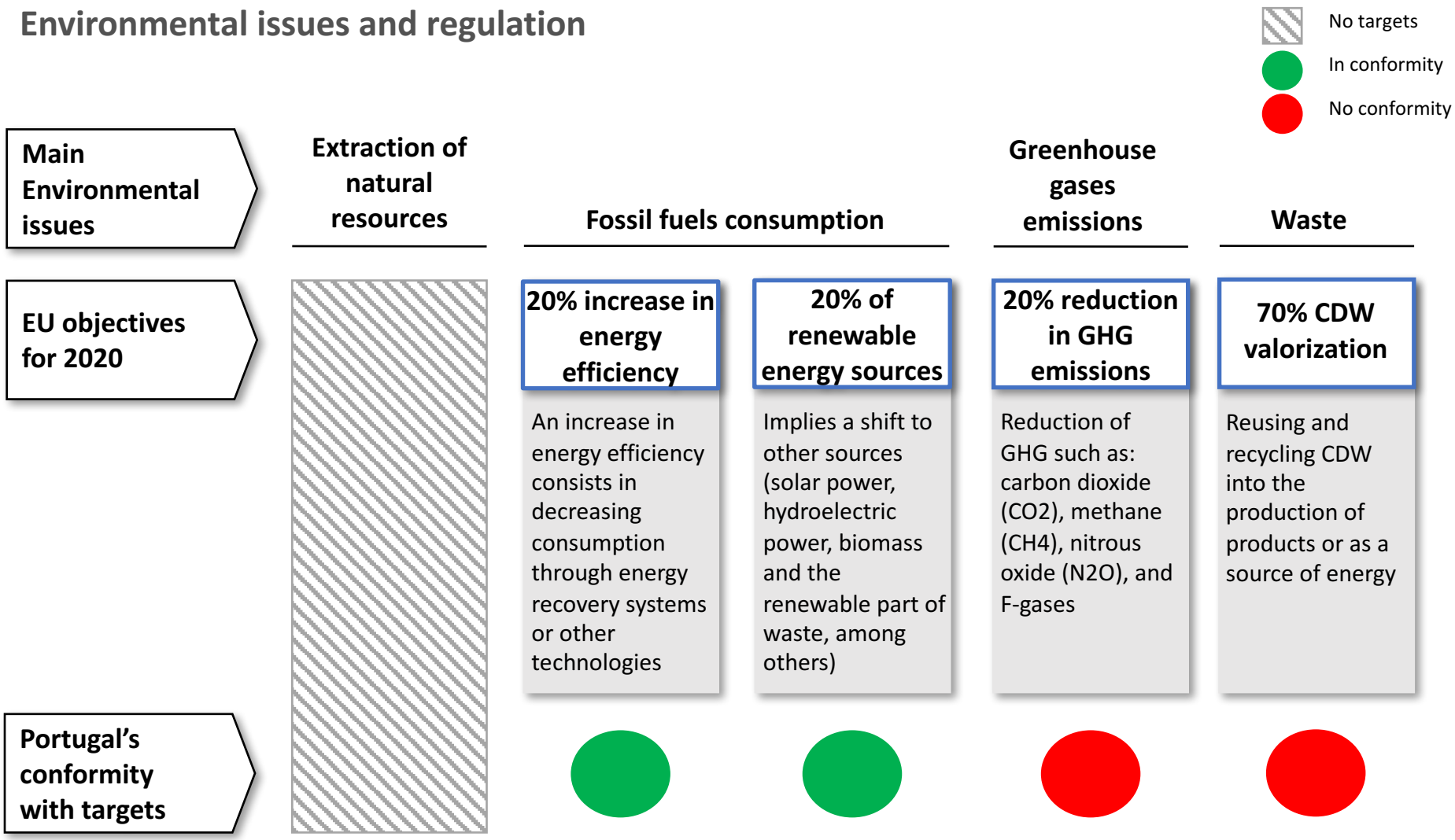
- The cement and materials industry **contributes to waste in 3 key economic activities,** which account for **73% of the global waste**
- The main problem of waste production relates to the fact that as of 2012, **34% of valuable waste that was lost through less favourable types of treatment**, such as incineration for disposal and landfill
- In the cement and building materials industry, the proper treatment of waste can lead to **savings concerning fossil fuels, GHG emissions and natural resources**

Source: Eurostat Report, Ecofys, Cembureau

Note 1: Excluding major mineral waste

Increasing environmental demands, mainly driven by the Paris Agreement, make it crucial for cement companies to redefine the current business model in order to ensure continuity in the medium and long run

Environmental issues and regulation

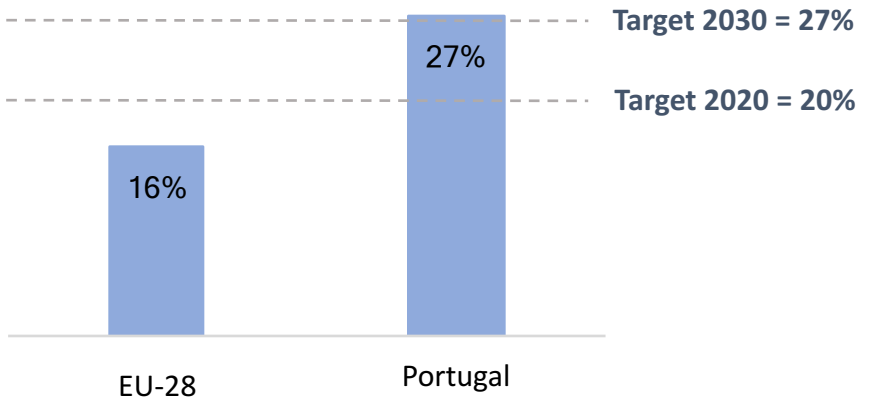


Source: Secil/NovaSBE team, European Commission

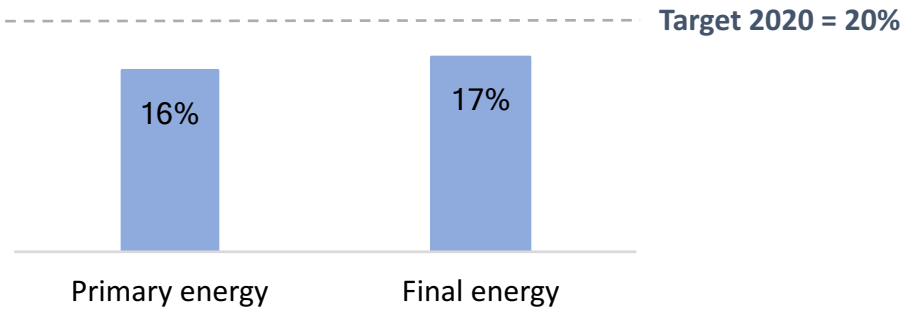
Portugal is already ahead of the EU renewable energy and energy savings targets

European Union Objective: Target of 20% of energy originated from other renewable sources and increase of 20% in energy efficiency

Percentage of renewable energy on gross final energy consumption in 2014 (% of total)



Percentage of primary and final energy savings in EU28 in 2014 (%)



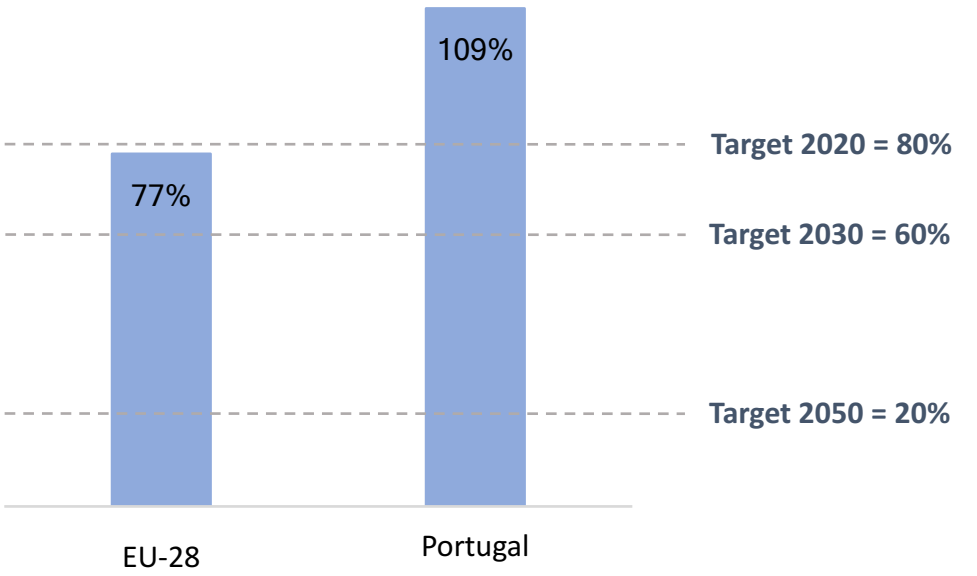
- Portugal already has a high production of energy from renewable sources and is above the target for 2020 with **27% of total energy** due to its more demanding national target of 31%
- In the cement and building materials industry, renewable energy comes mainly from biomass
- In terms of energy efficiency, Portugal already achieved a saving higher than the 20% target in 2014, in both primary and final energy savings

Source: Eurostat

Portugal is far from reaching the EU targets for GHG reductions and in fact has been growing its emissions

European Union objective: 20% reduction in greenhouse gases emissions

Emissions of greenhouse gases (Base year = 1990)



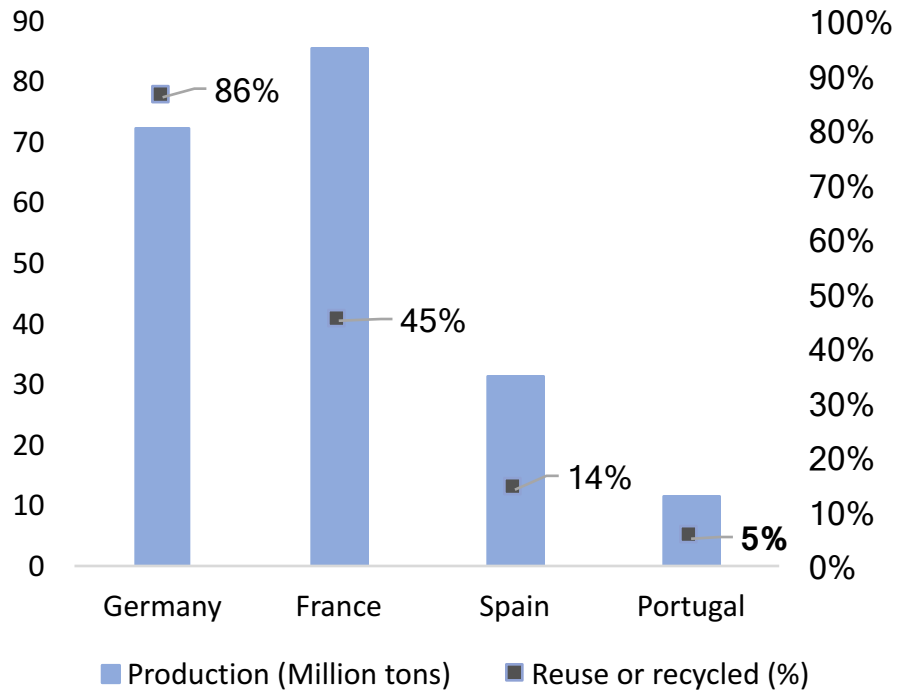
- The main greenhouse gases are Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O) and Fluorinated gases (F-gases)
- In the cement and building materials industry, **CO_2 is the biggest problem** due to the heavy use of fossil fuels, especially in the cement production process
- While most countries exhibit a decrease in emissions compared to 1990, **Portugal shows a significant increase**

Source: Eurostat

Portugal still has a long way to reach the EU targets for CDW reuse and recycling, which requires strong cooperation between the industry and the regulators

European Union objective: Target of 70% on Construction and Demolition Waste valorization rate

Quantity of generated CDW and percentage of reuse and recycling in Germany, France, Spain and Portugal (2011)



- The reuse or recycling of construction and demolition waste not only directly benefits the environment but can also **reduce the costs of producing concrete and other building materials**
- In Portugal, the construction and demolition waste valorization rate is around 5%, which clearly **requires a huge improvement to reach the 70% target for 2020**
- The lower cost associated with landfills, the lack of high quality recycled waste and the logistics needed to transport and recycle these materials, make this target a difficult problem to solve
- The solution to the problem will probably require specific regulation and incentives

Source: European Commission

In addition to the EU targets, the creation of a Carbon Tax consists in a possible threat to cement and building materials companies

Rationale behind a EU Carbon Tax

Greenhouse gases as the main cause for global warming (CO_2, methane, nitrous oxide and fluorinated gases)

The cost of purchasing fossil fuels is much lower when compared to renewable sources

The overall objective for limiting the average temperature rise of the planet to less than 2°C can only be achieved if countries reduce their greenhouse gases emissions, of which CO_2 is the main priority due to its weight in total greenhouse gases

The solution is to charge a Carbon Tax that will make companies consider the transition to renewable energy sources

The report from the Intergovernmental Panel on Climate Change (IPCC) shows the urgency for drastic changes and supports the implementation of the carbon tax:

- In order to remain below 2° C, emissions must decrease from 40% to 70% globally between 2010 and 2050
- Delaying additional mitigation to 2030 will substantially increase the technological, economic, social and institutional challenges associated with limiting global warming throughout the 21st century to below 2°C in relation to pre-industrial levels

Source: United Nations, Financial Times, Carbon Tax Center, The Washington Post

In addition to the possibility of a standard carbon tax, the cap allowances for industry emissions are likely to be reduced

The EU emissions trading system (EU ETS) is a policy created to fight climate change and reduce greenhouse gas emissions.

This system works on a **"cap and trade" principle**: a cap is set on the total amount of greenhouse gases emitted by each installation. This cap is in constant reduction overtime so that total emissions fall all over the world.

Each year, companies have to ensure they possess enough allowances to cover its emissions in order to avoid heavy fines.

Current ETS system

- Trades are allowed: when with remaining allowances companies can sell them to others in need, or even spare them to cover its future needs.
- Secil is far below its target having unused CO2 sales currently generating nearly **1% of Total Revenues** and representing **6% of EBITDA of Secil cement business in Portugal**
- The ETS is little effective - has not substantially reduced emissions
- Avoids low-carbon investments, since companies can cheaply purchase allowances elsewhere

Possible future system

- If this cap is reduced, companies will likely exceed their emissions limits and have serious consequences for their businesses:
  - Increasing costs for companies
  - Heavy weight on revenues
  - Reduction on production or increasing prices
  - Investment in clean, low-carbon technologies

Source: European Commission, Carbon Tax Center, Ecofys; Estimates done for Secil cement business in Portugal 2015

Concrete is the most used building material due to its inherent qualities/characteristics despite its high environmental impact

Main concrete characteristics

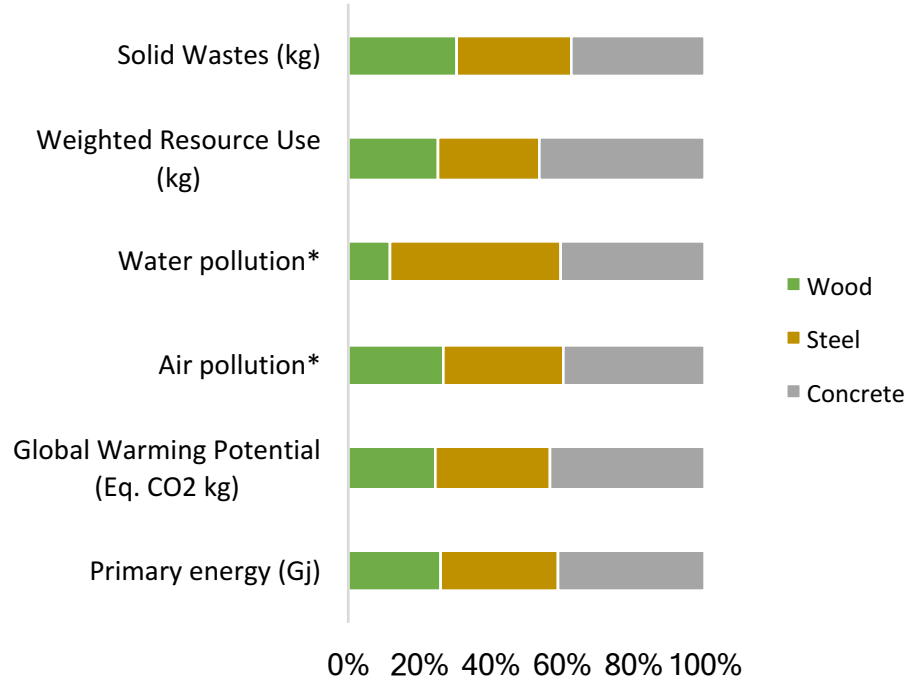
	Description
Strength	• Only concrete can be used for heavy structures such as buildings, bridges, tunnels and dams due to its strength
Workability	• A property of freshly mixed concrete that determines its working characteristics, i.e. the ease with which it can be mixed, placed, compacted and finished • Workability makes concrete a versatile material that can be used in many different types of structure and can produce many different shapes
Durability and safety	• Concrete, being inert, compact and non-porous, is not weakened by moisture, mould or pests over time • Concrete structures can withstand natural disasters such as earthquakes and hurricanes • Being naturally fire-resistant concrete forms a highly effective barrier to fire spread
Material availability	• Concrete and its ingredients are widely available in any native area
Cost effectiveness	• Compared to other comparable building materials (e.g. steel), concrete is less costly to produce and remains extremely affordable • The maintenance cost of concrete is very low
High environmental impact	• Although concrete is the most complete building material, its mixture requires cement and aggregates, which are raw materials that impose a great impact in the environment

Source: Secil/NovaSBE Team, World Business Council for Sustainable Development (WCBSD)

When compared to other "heavy" construction materials, concrete is not as harmful to the environment as it is perceived

Assessment of the environmental impact between wood, steel and concrete

Embodied Effects of wood, steel and concrete across environmental measures (% of total)

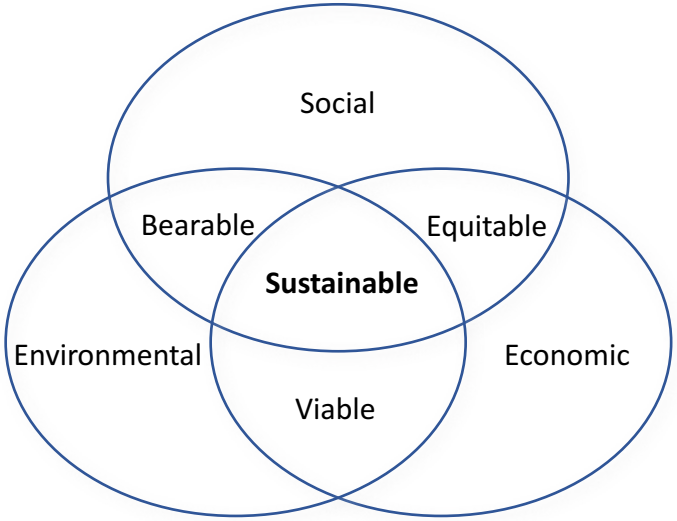


- Wood outperforms steel and concrete in all measures as construction materials
- Concrete has particular consequences for the environment regarding the **use of resources** and **greenhouse gases emissions**
- Concrete contributes to **29%** more greenhouse gases emissions, and uses **50% more resources** (from a weighted resource use perspective) when compared to wood
- Although concrete has the highest environmental impact, wood and steel also have a significant environmental impact and lack characteristics that make concrete the most used building material

Source: Secil/NovaSBE Team, Canadian Wood Council

The Sustainable development concept was created to help societies be aware that sustainability is only achieved if social, economic and environmental limitations are taken into account simultaneously

Sustainable Development and the Linear Economy



- Since the origin of the sustainable development concept, several restrictions were created with the goal of **reducing negative environmental and social externalities while maintaining economic viability**
- However, **the current Industrial economy follows a linear model of resource consumption**, which has a great environmental impact
- According to the OECD, approximately **65 billion tonnes of raw materials** entered the global economic system in 2010, and this figure is expected to grow to about 82 billion tonnes in 2020 (in terms of volume)
- The extraction of natural resources and other major environmental issues related to the linear economy make it crucial to re-think the current production and consumption model in order to achieve sustainability

Source: Ellen MacArthur Foundation

The problem is that the Linear Economy concept and its inherent business models will not be viable as environmental pressures increase

The Linear Economy and its limitations

The linear "Take, Make, Dispose" economic model

Description of the model

- **Companies** harvest and extract materials, use them to manufacture products, and sell products to consumers
- **Consumers** use the product and then dispose them when products no longer serves their purpose
- After disposal, a significant part of the waste is landfilled or incinerated, which means that all the value is lost

Main Driver

World's population growth

Problems

- **Natural resources scarcity**
- **Materials and energy**
- **Landfills and incineration**

Implications

The model is based on the assumption that resources can be always extracted but humanity is using natural resources faster than they can regenerate

The model represents an enormous waste of useful materials and energy that in most cases are not recovered

The model puts undue strain on limited landfill space and the incineration process contributes to the emission of pollutant gases

Source: European Commision, Ellen MacArthur Foundation

Current consumption and population trends will not be supported in the long term, thus making it clear that linear models will have to change

Problems of the Linear Economy in numbers

Demographic factors

8.5 B

By 2030, population is expected to **grow by 15% to 8.5 Billion** compared to current levels

5 B

By 2030, 3 billion people from developing countries will rise into the middle class, and the **global middle class will have approximately 5 Billion people**

Creation of an unprecedented global demand for **energy** and **resources**, and, consequently, an increase in **waste**

Environment-related factors

140 B

By 2050, around **140 Billion tons of natural resources** will be consumed per year – 3 times the current rate

3 B

By 2025, the quantity of waste produced is expected to **grow in 70% to 6 Million tons/day**

By 2030, moderate United Nations scenarios suggest that if current population and consumption trends continue, we will need **2 Planets** to support consumption levels at the current growth rate

Source: United Nations, United Nations Environment Programme, OECD, World Bank

The Circular Economy model appeared as a solution to sustainability limitations of the "take, make, and dispose" system by designing and optimizing products for multiple cycles of disassembly and reuse

The Circular Economy

Concept

A circular economy is **restorative and regenerative** by design, and aims to keep products, components, and materials at their highest utility and value at all times.

- Differentiate consumable and durable components of a product
- Consumables should return to the biosphere
- Durables should be reused indefinitely

Replace the "end of life" concept with restoration

- Toxic chemicals impair reuse
- Such chemicals cause environmental and health issues

Eliminate de use of toxic chemicals

Shift toward the use of renewable energy

- Decrease resource dependence
- Increase system resilience (e.g., to oil shocks)

Eliminate waste through superior design

- Superior design of materials products, systems and business models
- Design with the intention of disassembly and reuse
- Avoid the loss of value related to disposal and even recycling

Source: Ellen MacArthur Foundation

The Circular economy has the potential to turn the limitations of the linear model into economic, environmental and social benefits

From a Linear to a Circular Economy

Limitations of the Linear Economy

- Lost value of materials and products
- Scarcity and volatile prices of resources
- Continuously increasing amount of waste generated
- Unstable supply of raw materials
- Environmental degradation and climate change

Benefits of Circular Economy

- The **value of products, materials and resources is maintained** in the economy for as long as possible
- Waste generation is **minimized**
- **New business opportunities**, and introducing **innovative products and services**
- Creates economic, social and environmental gains

Source: European Commission

According to the Ellen MacArthur Foundation, the Circular Economy has three fundamental principles, each one addressing several of the resource and system challenges that industrial economies face

The three fundamental principles of a Circular Economy

Preserve and enhance natural capital

- **Control** finite stocks and **balance** renewable resource flows

Optimize resource yields

- Circulate products, components, and materials at the highest utility at all times in both technical and biological cycles
- Design for remanufacturing, refurbishing, and recycling to keep components and materials circulating in and contributing to the economy.

Foster system effectiveness

- Reveal and design out negative externalities, which implies **reducing** damage to human utility, such as food, mobility, shelter, education, health, and entertainment, and **managing** externalities, such as land use, air, water and noise pollution, release of toxic substances, and climate change.

Source: Ellen MacArthur Foundation

The "ReSOLVE" framework consists on a more practical approach with general initiatives aiming to achieve the three fundamental principles of the Circular Economy

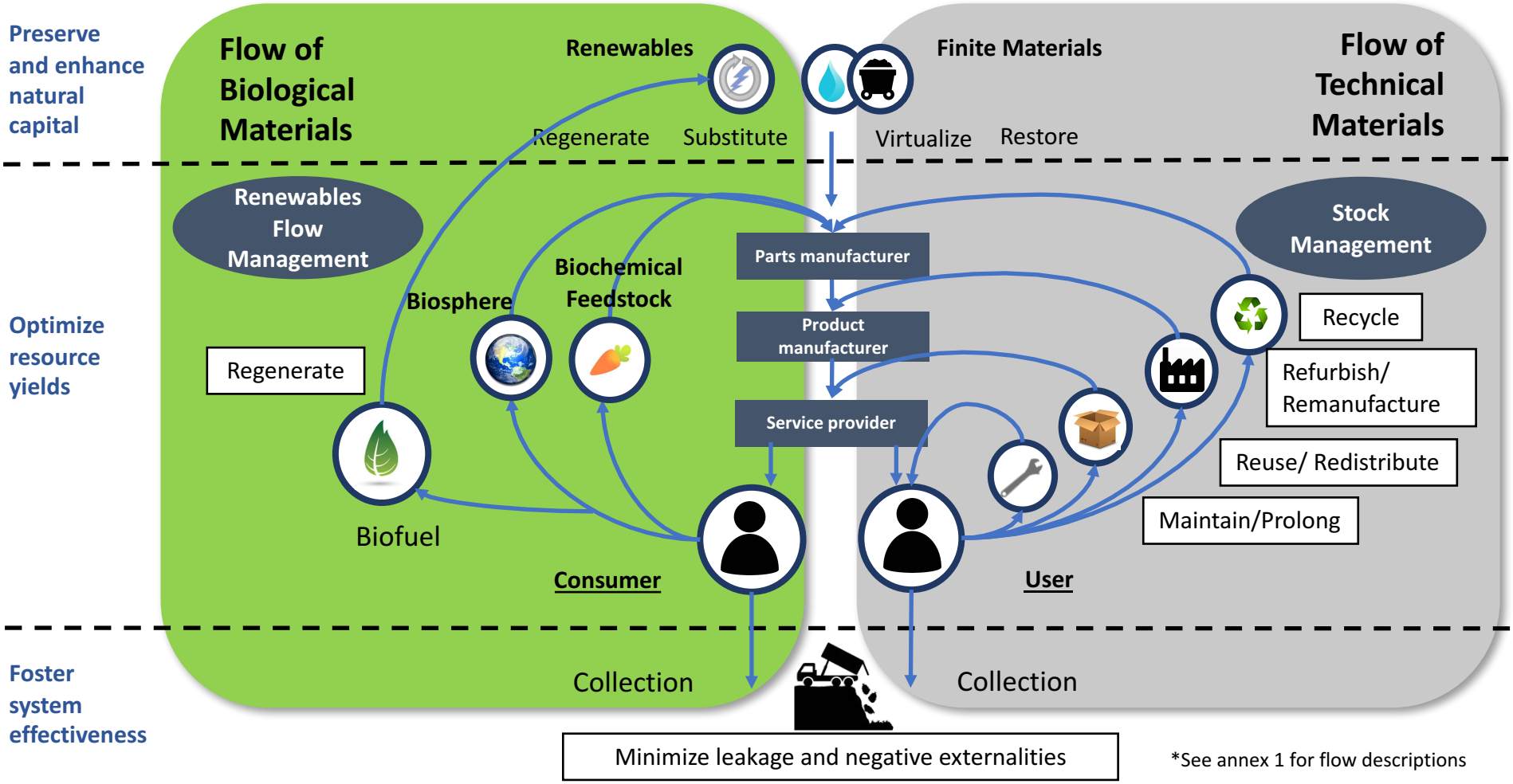
The "ReSOLVE" Framework: General initiatives to achieve the Circular Economy objectives

Initiative	Description
REGENERATE	• Shift to renewable energy and materials • Reclaim, retain, and restore health of ecosystems • Return recovered biological resources to the biosphere
SHARE	• Share assets (e.g. cars, rooms, appliances) • Reuse/second-hand • Prolong life through maintenance, design for durability, upgradability, etc.
OPTIMIZE	• Increase performance/efficiency of product • Remove waste in production and supply chain • Leverage big data, automation, remote sensing and steering
LOOP	• Remanufacture products or components • Recycle materials • Digest anaerobically • Extract bio-chemicals from organic waste
VIRTUALIZE	• Direct virtualization (e.g.: books, CDs, DVDs, travel) • Indirect virtualization (e.g.: online shopping)
EXCHANGE	• Replace old with advanced non-renewable materials • Apply new technologies (e.g.: 3D printing) • Choose new product/service (e.g. multimodal transport)

Source: Ellen MacArthur Foundation

The system diagram illustrates the continuous flow of technical and biological materials through the 'value circle', making clear the key initiatives that should be taken at each phase of the process

The Circular Economy System Diagram*



*See annex 1 for flow descriptions

Source: Adaptation from the Ellen MacArthur Foundation Diagram

The transition into a Circular Economy principles can lead to benefits in the economic, environmental and social dimensions

Key Figures and Facts about the Circular Economy

Economy

- In Europe, the adoption of the circular economy principles can yield **annual benefits of up to €1.8 trillion by 2030** due to the potential reduction in annual primary resource costs, cash-out costs and external externalities
- European **GDP could increase as much as 11 percent by 2030 and 27 percent by 2050** in a circular scenario, compared with 4 percent and 15 percent in the current development scenario

Environment

- **Reduction of CO_2 emissions of 48% until 2030, and 83% until 2050**, regarding systems of mobility, food and construction
- **Primary material consumption** measured by car and construction materials, synthetic fertilizer, pesticides, agricultural water and land use, fuels and non-renewable electricity, and land for real estate could drop as much as **32 percent by 2030 and 53 percent by 2050**

Social

- The adoption of the circular economy model reduces the environment impact of many industries, which contributes to an increase in human well-being - **reduction of health issues (related to air, land and water pollution), and maintenance of important natural resources**
- The potential value and job creation can lead to an increase in disposal income of families, which also contributes to an increase in human well-being

Source: Ellen MacArthur Foundation

Clear drivers are making the Circular economy model increasingly attractive for several industries, with companies already observing opportunities to explore

Drivers of the Circular Economy and Market Drivers

Circular Economy Drivers

- Scarcity and increasing difficulty to extract natural resources
- Sharp increase in raw material price and volatility
- Increasing environmental regulation and standards
- Pervasive shift in consumer behavior
- Continuous advances in information technology

Why are Industries interested in the CE?

- Efficiency in their global supply chain, produce quality, quantity and consistency of a secondary raw material
- Be in a win-win situation, create value
- Brand image
- Risk management (raw material shortage, disruption in the supply chain, etc.)
- Environmental efficiency (elimination of toxic material, avoid accumulation of toxicity, CO2 footprint, energy efficiency, water re-use, etc.)
- Innovation

Source: Ellen MacArthur Foundation

Some characteristics of the current linear economy arise as challenges to accelerate the transition towards the circular economy across global supply chains

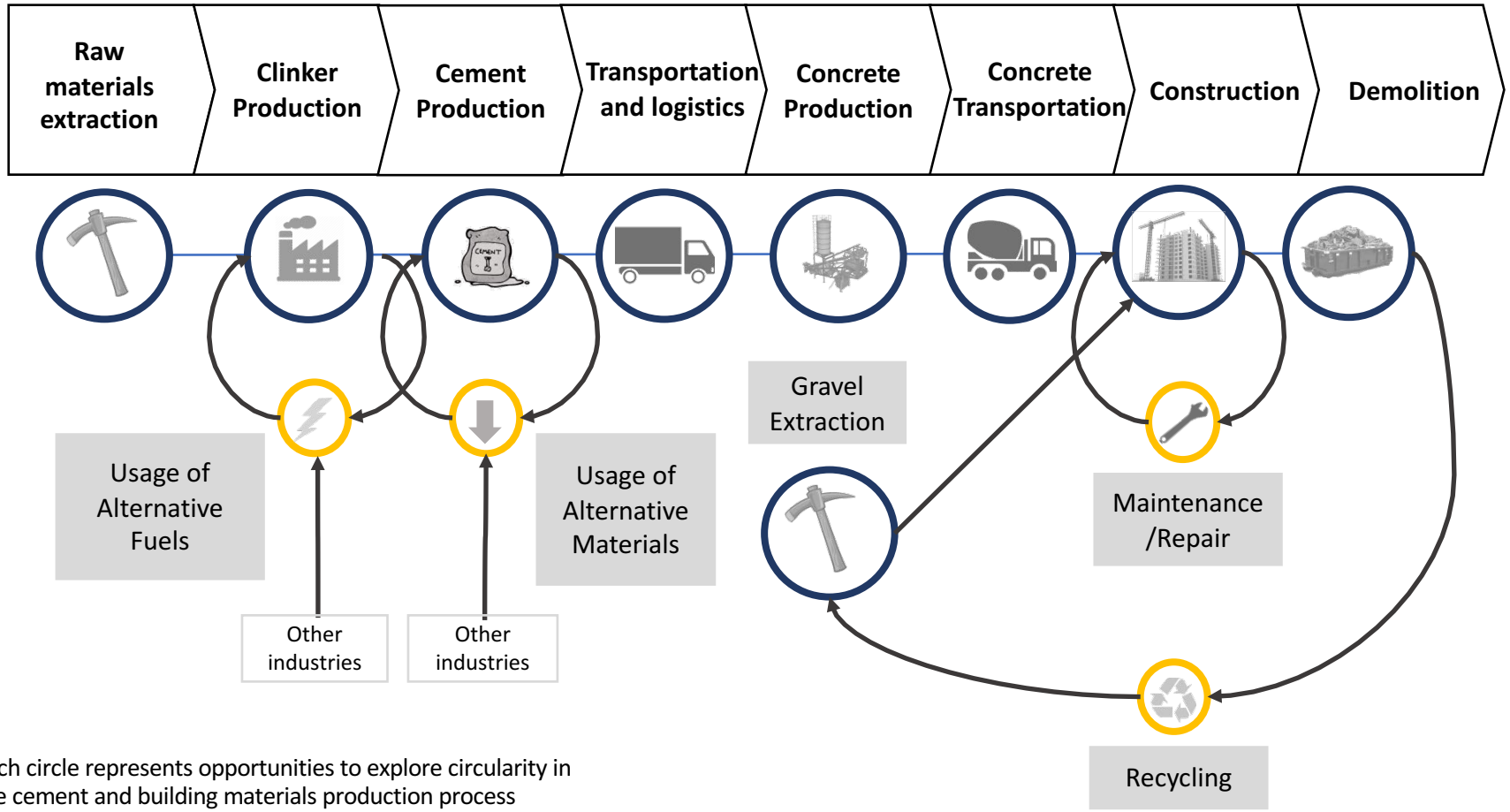
Challenges of the Circular Economy

	Description
Geographic dispersion	• The size, complexity and global dispersion of supply networks • For reverse logistics, take-back or other initiatives to work globally, various legislations need to be synched
Material complexity	• Complex formulations (multiple materials and built-in functionality) paired with the lack of labelling make post-consumer material identification and tracking difficult • Inability (or difficulty) of separating and recuperating valuable materials from the recovery process
Linear lock-ins	• Misalignment of incentives • Lack of markets at scale • Lack of reverse capabilities and infrastructure

Source: "Intelligent Assets Unlocking the Circular Economy Potential", Ellen MacArthur Foundation

Although the cement and building materials industry is very polluting and faces many challenges, it provides an irreplaceable good and there are opportunities to explore circularity in its production process

Circular Economy applied to the Cement and Building Materials Industry



Each circle represents opportunities to explore circularity in the cement and building materials production process

Source: Secil/NovaSBE Team.

Based on the "ReSOLVE" model, the Team developed the "7 Rs" framework to better assess initiatives with great and specific impact to the cement and building materials industry

The "7 Rs" Proposed Framework

Drivers	Description
REDUCE	• Consumption reduction or substitution of specific products which have the highest impact for the environment
RECYCLE	• Recycling waste and end products; recovering and converting waste into reusable materials or products
REMANUFACTURE	• Change on the product manufacturing process and design to create solutions with less impact on the environment
REUSE	• Reuse of products, materials or energy in the production process that would be wasted otherwise
RETAIN / PROLONG	• Design smarter products and solutions with a longer lifetime value, promoting maintenance and repair instead of substitution and disposal
REFINE / OPTIMIZE	• Development of products that reduce or influence positively energy consumption and resources during its lifetime
RECOVER/RESTORE/ REGENERATE	• Recovery or restoration of resources used in the production process. Reduction of the long-term environmental footprint

Source: Secil/NovaSBE Team.

The Team identified initiatives aiming to reduce environmental impact and promote circularity

Initiatives that Secil could implement across the whole value chain

NON EXHAUSTIVE

Drivers		Initiatives
Reduce	1	Replace cement / concrete by other materials (wood, steel, glass, ceramics, asphalt, bitumen, etc.)
Recycle	2	Recycle the end product and components (concrete)
Remanufacture	3	Adopt 3D printing as an alternative building technology
	4	Usage of alternative fuels
	5	Replace clinker/cement with alternative raw materials (slag, fly-ashes, etc.)
Reuse	6	Reuse heat / energy / water released in the process
Retain and Prolong	7	Rehabilitate buildings (instead of building new ones)
	8	Construct buildings with longer lifespan
Refine / Optimize	9	Concrete that absorbs CO_2
	10	Construction of more efficient buildings that optimize energy consumption during its lifetime
	11	Carbon Capture and Storage (CCS)
Recover / Restore / Regenerate	12	Landscape recover and rehabilitation (landfills and quarries)

Source: Secil/NovaSBE Team.

In orderto scope the initiatives and its main hypothesis the team applied a planned methodology to each sing initiative

Three main phases of the process

Phases	Phase 1	Phase 2	Phase 3
Objectives	• Understand the Circular economy concept based on the Ellen MacArthur framework • Develop a specific framework for the Building Materials Industry – 7 R's Framework	• Identify relevant industry initiatives for each of the "R" drivers • Analyze the potential and the impact for both business and environment	• Select the most relevant initiatives to develop based on its stage of development and on the impact for Secil • Understand the potential recommended approach for Secil and the expected implementation challenges

Based on Team Research and Expert Interviews

Source: Secil/NovaSBE Team.

Reduce: Replace cement / concrete by other materials

Description

Substitution of concrete due to the negative impact it has on the environment. Reducing the use of concrete (and consequently of cement and aggregates) by replacing it with other materials such as **wood, glass, steel, ceramics, asphalt or bitumen**.

This initiative becomes even more relevant if the other industries are able to develop more sustainable practices and if new regulation is created on this area.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
Decreased usage of natural resources, such as limestone, gravel, clay and water and Increased use of other natural resources (wood, fuel)	Decreased usage of fossil fuels due to decreased cement production	The reduction of clinker production implies a decrease in GHG emissions	Waste from other materials can be less harmful to the environment (ex: wood)

Impact on materials

The reduction of concrete production will also result in the reduction of cement and aggregates

Relevant Contingencies

"This initiative must be taken with a grain of salt because other substitutes to cement can be more harmful to planet than the cement itself. In order to build with wood we need to take down forests, steel is much more pollutant in its making process" – **Eng. Dina Frade**

Source: Secil/NovaSBE Team

Wood as a trendy green alternative material worldwide

Wood still retains some advantages over more industrial building materials like concrete or steel:

- Requires much **less energy-intensive** methods to process into construction products
- Wood is **environmental friendly** since it's renewable and can ensure a biodiverse habitat. Trees also absorb CO_2 as they grow, making it carbon negative
- This material is 5 times more insulative than concrete, meaning less energy is needed to heat and cool a wood building
- There is also the aesthetic appeal of wood—its earthy colors and aromas, fine grains, durability, dimensional stability, workability and cost effectiveness
- However, for larger, more robust buildings and infrastructures, concrete is far more solid and lasts longer

Source: Society of Wood Science and Technology

Recycle: Recycle the end product and components (concrete)

Description

Recycling concrete consists in transforming **construction and demolition waste** into new aggregates, thus replacing a fraction of the gravel extraction.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
Reduction of natural resources usage, such as gravel and Increased use of other natural resources (wood, fuel)	May need to incorporate more cement into concrete and/or it is necessary to count the energy consumed to process the waste	No apparent impact	Use (part of) the construction and demolition waste

Impact on materials

May change the required concrete composition (more cement) and increase its production costs

Relevant Contingencies

"We are fully capable of storing and recycling construction and demolition waste. The problem is that we need that companies bring us that waste. We can even use the reverse logistics. The problem is that the landfill costs are so cheap that companies have no incentives to recycle their waste" – **Eng. Pedro Martins**

"Incorporation of recycled materials in cement production is limited due to the inherent decrease in the quality of the product – The maximum insertion is about 5%." **– Eng. Maria João Botelho**

Source: Secil/NovaSBE Team, The Cement Sustainability Initiative (CSI)

Remanufacture: Adoption of 3D printing as an alternative building tecnology

Description

3D Printing can have a huge potential if it enables significantly lower costs and time of construction. This innovative method is still in a development stage but there are already final projects showing how disruptive this technology can be for the construction sector. Initially, the main material used in the printing was cement but there is the possibility of using other materials, such as plastics and metals, and even recycled concrete.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
Decreased use of natural resources due to optimization and reduction of waste in the process	Decrease in the use of fossil fuels, derived from the reduction in cement production	Less clinker production with the replacement of cement for other materials, implying a reduction in the emission of gases into the atmosphere	The accuracy and efficiency of 3D printing means less waste in the construction and manufacturing process

Impact on materials

Optimization and replacement by other materials has a major impact on all cement products

Relevant Contingencies

"3D printing is surely good for environment since we can have a direct influence on the doses used in the final mixture and the printer precision and efficiency make waste during construction almost non-existent. It can even use recycled concrete" – **Eng. António Nunes**

"This is a game changer. It can shape the entire industry" **– Mr. Fernando lopes**

Source: Secil/NovaSBE Team, 3D Printing Industry

Example - 3D Printing has the potential to drastically change the construction industry

10 small houses built in less than **24 hours costing less than 5000$ each**

Each floor took **one day** to be produced ”off-site” and assembled

This construction took about **90 days** and cost **161 000 $**

Assembled in just **3 hours**

Source: 3D Printing Industry, CNET

Example - 3D Printing is very flexible and can adapt to most construction needs

- System is based on “Lego” type pieces that are designed to be assembled in an “Ikea” way
- First office building printed by a 3D printer
- Took **17 days** to be produced and cost about **140 000 $**
- Assembled in less than **2 days**
- The UAE Prime-minister intends to have **25% of all Dubai buildings 3D printed**

Source: CNET

LafargeHolcim invested in a 3D concrete printing venture

Recently, LafargeHolcim has partnered with the French start-up XTreeE, specialized in large-scale 3D printed projects:

- This partnership made possible the **first 3D concrete printed creations in Europe**
- The first one is a load-bearing post, with a height of 4 meters, to support the playground roof of a middle school in France
- The latter is a pavilion with a revolutionary design created for Ile-de-France regional authority

Source: LafargeHolcim website

Remanufacture: Usage of alternative fuels

Description

Instead of using the most common fossil fuels, such as coal and petroleum derivatives (petcoke) in the production of cement, it is possible to use **fuels, tires, biomass** or even **garbage**, for the same purpose. These alternative fuels will generate less impact on the environment, since the use of renewable energy in the production process contributes to a lower consumption of fossil fuels and, consequently, reduces CO_2 emissions.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
No impact	The usage of alternative fuels, such as tires and biomass, reduces the usage of fossil fuels	Reduction of GHG emissions by burning alternative fuels. Renewable energies will reduce the emissions as well.	There is a waste reduction since waste from other industries will be used.

Impact on materials

Significant impact on cement. Not only reduces environmental costs, but production costs as well.

Relevant Contingencies

"It is possible to run a kiln purely on alternative fuels. In order to do that we would need a new kiln and the cost of production would greatly increase since coal and petcoke are much cheaper" – **Eng. Ângela Nunes**

"Renewable fuels, such as Biomass, do not have the required calorific properties to heat up limestone in the clinker production process – other fuels are indispensable." – **Eng. Maria João Botelho**

Source: Secil/NovaSBE Team, Cembureau

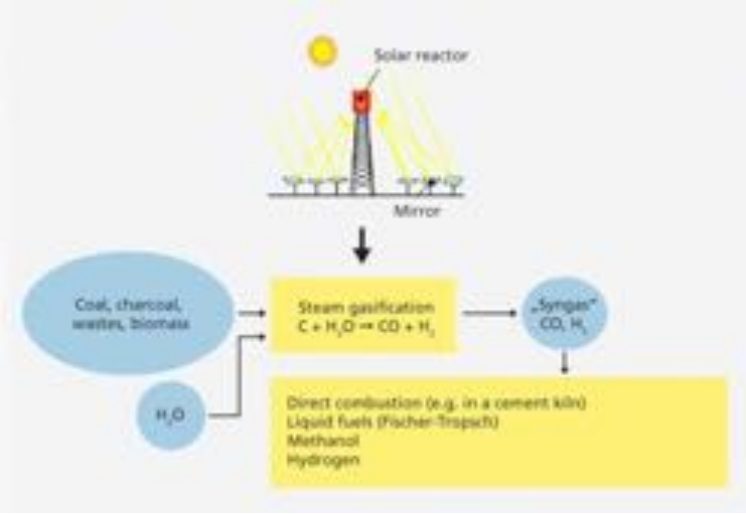
Example – Solar Energy as Fuel

Holcim in partnership with leading Swiss research institutes **Paul Scherrer Institute** and **ETH Zurich** are developing "solar cement"

- "Solar steam gasification" consists in the production process of *syngas* through solar energy, becoming an excellent fuel that can be used for heating cement kilns

- Syngas is produced by adding raw materials such as coal, waste or biomass with the solar energy, generating carbon. Its reaction with water vapour is called *syngas* (carbon monoxide and hydrogen)

One of the advantages of this technique is that *syngas* contains more 40% of energy when compared to waste used as fuel



Source: Paul Scherrer Institute, Holcim

Remanufacture: Replace clinker/cement with alternative raw materials

Description

To produce cement it is necessary to extract natural resources, such as limestone, sand and clay. Alternatively, waste from other industries such as **fly ash** and **slag** can be used, which reduces the use of clinker or cement, while eliminating waste from other industries at the same time.

Incorporation of alternative raw materials has 3 different outcomes:

- Reduction of the weight of clinker on cement
- Reduction of the weight of cement in the end product due to more durability or quality provided by alternative materials
- Performance enhancer – it is proven than the usage of raw materials has a positive impact on the concrete performance.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
Reduction of the extraction of natural resources (limestone and other raw materials) due to the decrease in the production of clinker.	Reduction of clinker production and, consequently, in the usage of fossil fuels.	The decrease in clinker production also translates into a decrease in CO_2 emissions.	Waste reduction – ash and slag are waste from other industries

Impact on materials

Significant impact on cement costs and quality (positive). Not only reduces the environmental impact of the cement industry but it also reduces cement production costs.

Relevant Contingencies

"Secondary raw materials, such as slag and flying ash, are either available in low quantities in the market or have a price which makes it inviable, respectively."– **Eng. Raquel Nascimento**

"Cork waste has a huge commercial potential since it is a trendy material that has acoustic and thermal properties. If used it also solves a problem of waste in the cork industry while at the same time reduces the weight of cement on concrete" **– Eng. Ângela Nunes**

Source: Secil/NovaSBE Team, Cembureau

Reuse: Reuse the heat/energy/water released in the production process

Description

During the cement production process, energy is generated, especially on the form of heat, which can be reused. In the same way, water used in the process can be reused.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
Water reuse, thus implying a reduction in the extraction of water	With the reuse of heat, fossil fuels are spared.	By decreasing the usage of fossil fuels, CO_2 emissions are reduced as well	No impact

Impact on materials

Reduces environmental-related costs of cement

Relevant Contingencies

"In the factories we already reuse much of the heat and steam generated in the process" – **Eng. António Nunes**

"We would not have significant benefits to invest in more efficient systems given that Secil already captures most of the potential to reuse energy in its industrial facilities. It's mostly marginal gains." – **Mr. Fernando Lopes**

Source: Secil/NovaSBE Team

Retain/Prolong: Rehabilitation of buildings

Description

Option to rebuild or rehabilitate a building at the end of its useful life. In the case of rehabilitation (instead of demolition and construction of a new one), there is less consumption of concrete/cement in return for a higher consumption of other building materials (ex: mortars).

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
Decrease in the production of cement and, consequently, in the extraction of natural resources.	Cement production reduction implies the reduction in the usage of fossil fuels.	Less cement production implies a decrease in the production of clinker, which, in turn, reduces emissions of gases.	Rehabilitation, as an alternative to demolition, implies a reduction of waste.

Impact on materials

The rehabilitation of buildings will lead to a reduction in the consumption of cement and concrete.

Relevant Contingencies

"Rehabilitation is much more focused on mortars and downstream solutions than cement itself" – **Eng. Dina Frade**

"We need to place ourselves much more downstream in the value chain and create diversified solutions that fit each project needs" – **Eng. Dina Frade**

Source: Secil/NovaSBE Team

Retain/Prolong: Construction of buildings with longer lifespan

Description

Use of raw materials that increase the durability and strength of the cement, thus increasing the longevity of the final construction. By building more durable and sturdy buildings, we are reducing the need for long-term cement production and hence its environmental impact.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
The reduction of the production of cement in the long term implies a reduction of natural resources, such as limestone and clay.	Reduction in the usage of fossil fuels, derived from a lower cement production.	Reduction of polluting gases emissions.	The lower need for demolition will reduce construction and demolition waste

Impact on materials

It will imply an increase in quality and cost of cement.

Relevant Contingencies

"Building with an emphasis on quality and durability is crucial. In order to do that we would need to provide a service where we would guarantee that our products are properly used and applied" – **Eng. Dina Frade**

"Buying some products from Secil but using other low quality materials can damage the company image over time" **– Eng. Maria João Botelho**

Source: Secil/NovaSBE Team, Portland Cement Association

Refine: Concrete that absorbs CO_2

Description

The possibility of producing cement or concrete that has the capacity to absorb CO_2 from the atmosphere could reduce the industry's environmental footprint. Although there are studies being developed to enhance the absorption of carbon dioxide in the production process, the concrete itself already absorbs CO_2 during its lifetime. It's a natural process called carbonation – since its production process is made by decarbonating limestone, over its lifetime is natural that concrete carbonates again, absorbing CO_2 from the atmosphere.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
No impact	Depending on the production process, there could be changes in the use of fossil fuels	Although production emissions remained the same, this would make cement production much more sustainable	No impact

Impact on materials

This type of concrete will increase its cost because it requires a more complex formulation with other costly materials

Relevant Contingencies

"Cement and concrete naturally absorb CO_2. It is a natural chemical process. Cement is decarbonized in the production process and, to restore balance, cement will carbonize (absorb CO_2) during its lifetime" – **Eng. Raquel Nascimento**

"If we made concrete absorb CO_2 it would mean that the steel structures inside the concrete would have a much faster corrosion, lowering durability" – **Eng. Dina Frade**

Source: Secil/NovaSBE Team

Example – Concrete that absorbs CO_2

Standard cement is produced by heating limestone or clay at 1500 to 2000ºC, releasing 800 kg of CO_2 per ton of cement

Novacem's cement is produced with magnesium silicates - which is a raw material that requires half of the temperature needed to heat limestone, and also absorbs CO_2 while it hardens

According to Novacem, a company originating from the Imperial College of London, this product's typical emissions are of -50kg to +100kg CO_2 /ton cement, meaning it absorbs about 600 kg of CO_2 per ton of cement.

Source: Novacem

Refine: Construction of more efficient buildings that optimize energy consumption during its lifetime

Description

The construction of houses with materials that have a high thermal capacity will enable these houses to be much more efficient from an energetic perspective.
This topic becomes especially relevant when embedded in a service throughout the chain and building lifecycle rather than just selling products.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
No impact.	Energy efficiency will imply a reduction in the usage fossil fuels	The reduction of fossil fuels usage will cause a reduction of CO_2 emissions	No impact

Impact on materials

Increase in the cost of cement and concrete due to a more complex formulation with other costly materials

Relevant Contingencies

"Concrete structures are much more thermal and energy efficient in the long term than wood or steel structures" – **Eng. Ângela Nunes**

"Cement can be mixed with almost anything, enabling the production of concretes that can have thermal, acoustic or even lightweight properties depending on the country and area of construction" **- Eng. Ângela Nunes**

Source: Secil/NovaSBE Team, WBCSD

Refine: Carbon Capture and Storage (CCS)

Description

Carbon Capture and Storage (**CCS**) is a technology that allows the capture of about 90% of the CO_2 emissions produced during the cement production, and deposit it underground.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
No impact	No impact	This type of technology reduces CO_2 emissions to the atmosphere	No impact

Impact on materials

Will increase cement cost of production having, therefore, influence on concrete and mortars cost

Relevant Contingencies

"This is just delaying a problem by burying CO_2 in the ground instead of sending it to the air " – **Eng. Dina Frade**

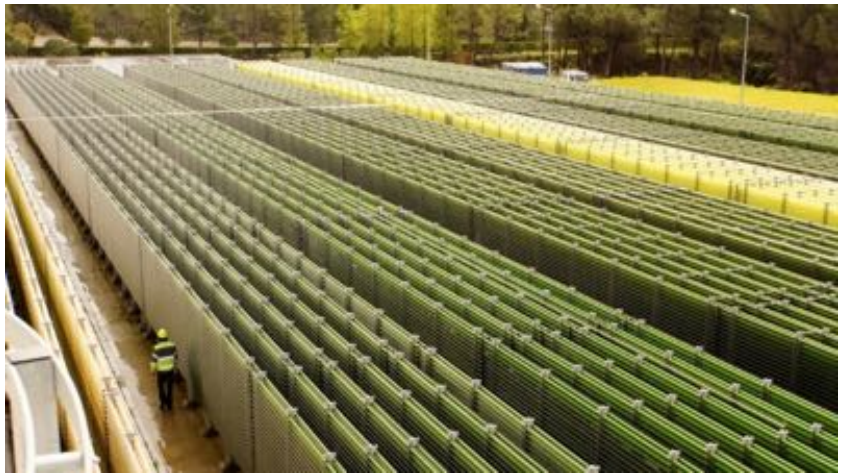
"It is not viable economically nor environmentally, but it is possible, yes" **- Eng. Ângela Nunes**

"Secil made a strong investment on carbon capture and recycling by using microalgae to absorb CO_2 and create biochemical compounds used in other industries" – **Eng. António Nunes**

Source: Carbon Capture and Storage Association

Example – Creation of microalgae for CO2 absorption

In order to sequester the carbon dioxide emitted by cement production, Secil has invested around 15 million euros in a process that uses microalgae to absorb part of the released CO2 and at the same time creates value-added products for other industries



The commercialization of microalgae - for the different markets that use them as a sustainable, natural ingredient rich in various biochemical compounds - will be a business activity centralized by the company Allmicroalgae - Natural Products, a unit belonging to Secil

Source: Secil-Group Website

Example - Carbon Capture and Storage (CCS)

Examples of operational commercial-scale CCS plants in the world and capture of CO_2 emission per year

Plant	Site	CO_2 emissions captured per year (M/Ton)
Val Verde Natural Gas Plants	Texas, EUA	1,3
Enid Fertilizer	Oklahoma, EUA	0,7
Shute Creek Gas Processing Facility	Wyoming, EUA	7
Sleipner	North Sea, Norway	1
The Great Plains Synfuels plant and Weyburn-Midale Project	Saskatchewan, Canadá	3
In Salah	Algeria	1
The Snøvit plant	Norway	0,7
Century Plant	Texas, EUA	8,5

This technique can reduce CO_2 emissions in its plants up to 40%. The process of capturing and storage CO_2 has 3 phases:

- Carbon Dioxide capture
- Transportation
- Storage CO_2 underground

Companies investing in CCS:

- **Heidelberg** as pioneer in this technology in **Norcem** plant, **in Breivik**
- **Joule Project** – Pioneer in transforming its emissions in fuels. Uses solar energy, non potable water and bacteria to produce fuel
- **Calera –** company that captures CO_2 and converts it in calcium carbonate, so it can incorporate it in its cement and produce cement materials with it.

Source: Carbon Capture and Storage Association, Joule Unlimited

Recover/Restore/Regenerate: Landscape recover and rehabilitation (landfills and quarries)

Description

Companies can recover the landscapes of landfills and quarries, minimizing its implicit environmental impact.

Impact on the environment

Natural resources	Fossil Fuels	Carbon Dioxide	Waste
No impact	No impact	No impact	The recovery implies an efficient use of the waste in these locations

Impact on materials

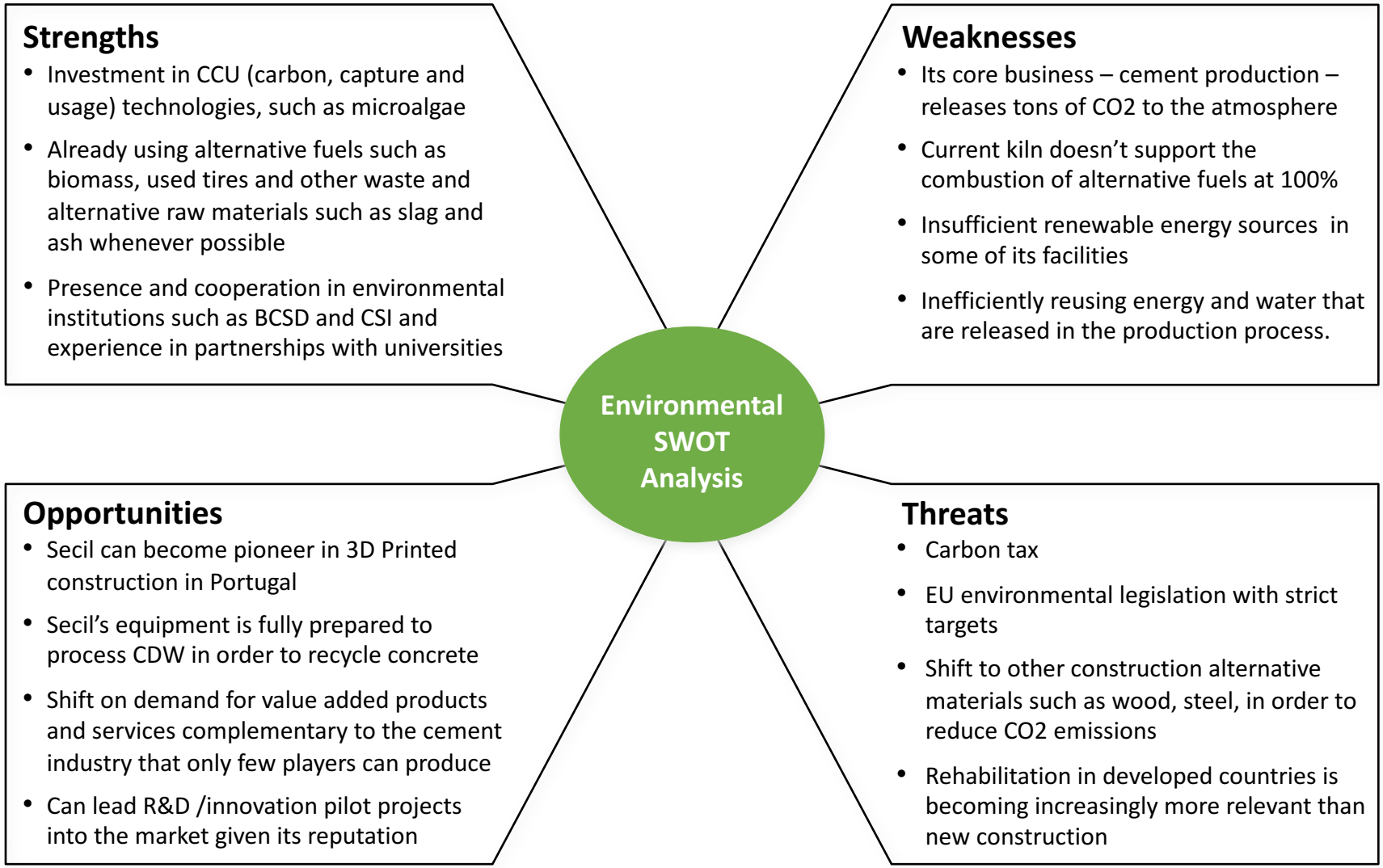
It has an impact on the costs associated with the extraction of raw materials from both aggregates and limestone.

Relevant Contingencies

"There is already legislation for this initiative. Secil rehabilitates and restores all its quarries by planting new trees and contributing to biodiversity in rehabilitated landscapes" – **Eng. Raquel Nascimento**

Source: Secil/NovaSBE Team

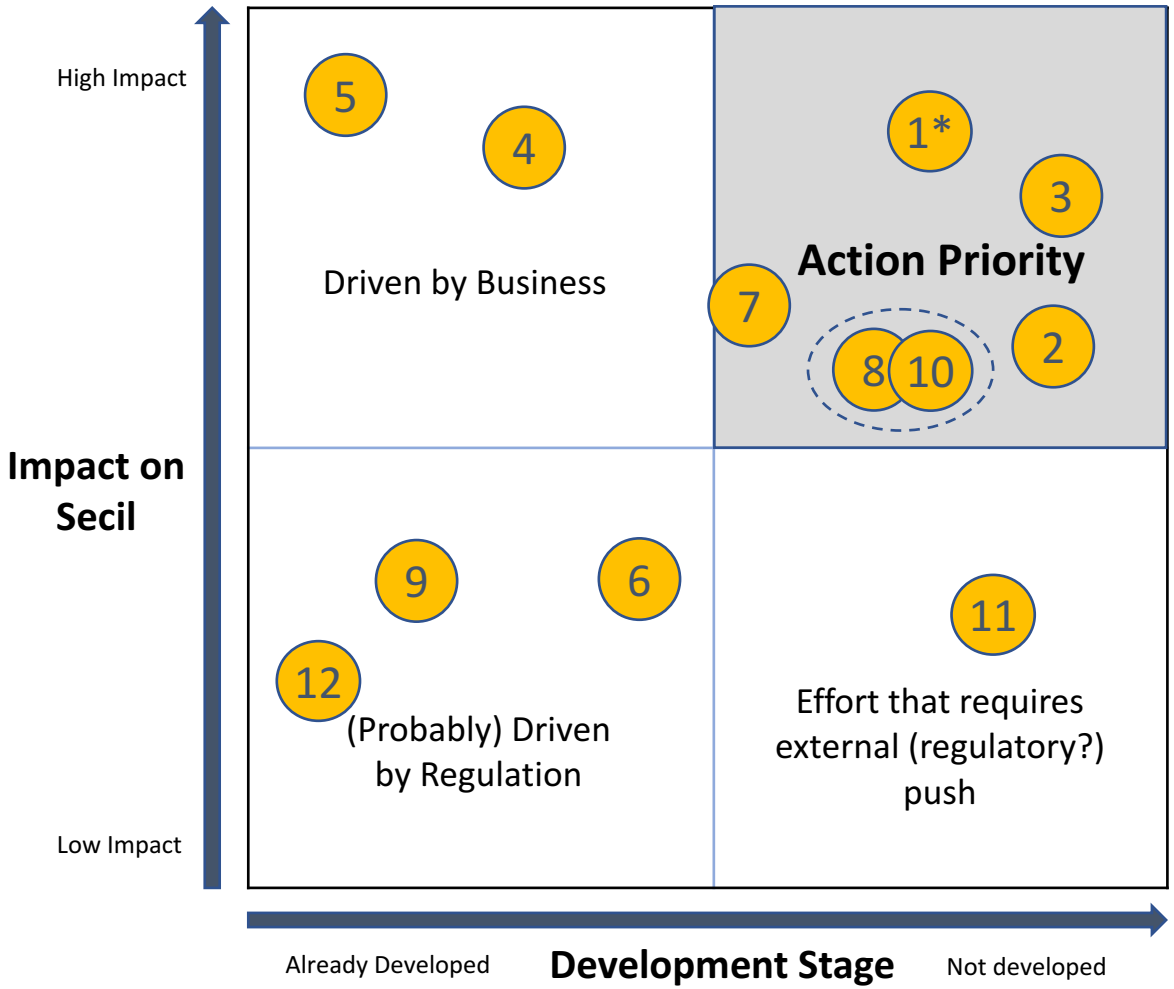
Given the strict environmental context that the industry is facing, an assessment of Secil's position to face these issues can be done with a SWOT Analysis



Source: Secil/NovaSBE Team

Secil should focus its efforts on the initiatives that are still at a early development stage and that can have a significant impact on its business

Priority Matrix



Priorities to be further explored

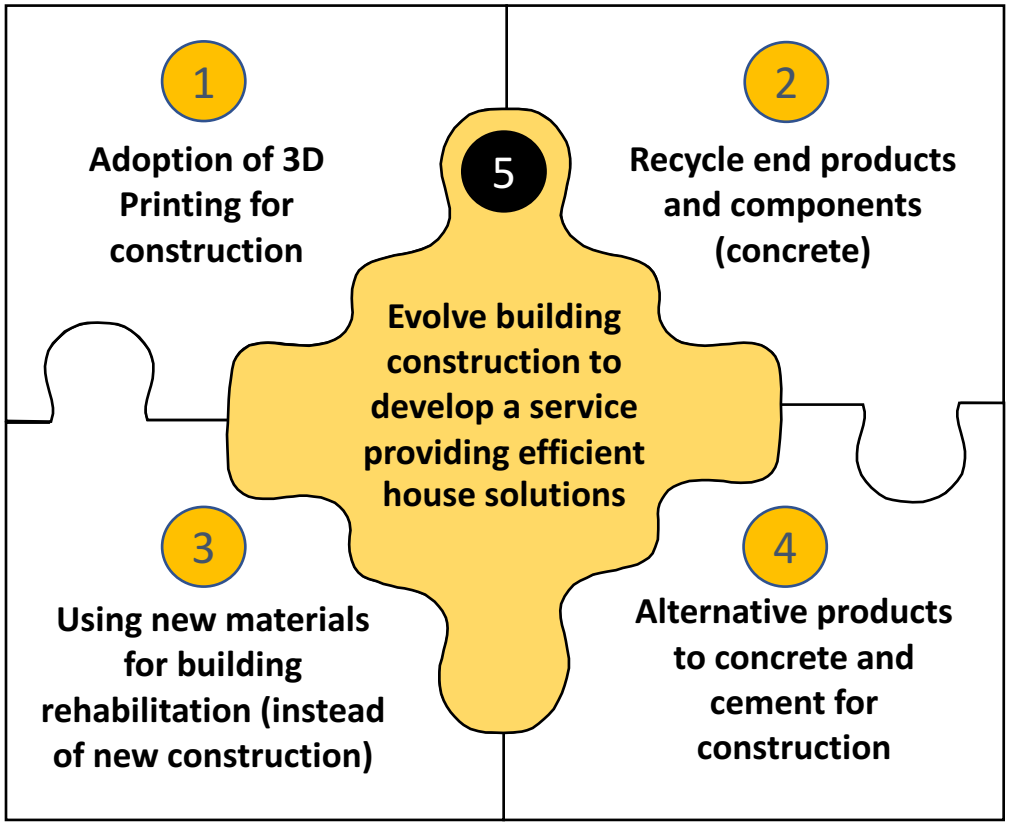
1. Replace cement by other materials
2. Recycle concrete
3. 3D printing
4. Usage of alternative fuels
5. Replace clinker/cement with alternative raw materials
6. Reuse heat / energy / water
7. Rehabilitate buildings
8. Construct buildings with longer lifespan
9. Concrete that absorbs CO_2
10. Energy efficient buildings
11. Carbon Capture and Storage (CCS)
12. Landscape recover and rehabilitation

1* - Initiative will not be considered as stated initially

Source: Secil/NovaSBE Team

The priority matrix clearly identified what are the initiatives or group of initiatives that have the most impact and importance for Secil

The Five Priorities for the Future



Source: Secil/NovaSBE Team

Adoption of 3D Printing for construction (1/2)

Initiative description

- A 3D printer is used to print the building in a special concrete mixture, layer by layer
- The printer can also pre-cast large pieces at the facility and then assembly is done on-site
- Several final projects have already been assembled in countries such as China and United Arab Emirates
- If operating at scale this technology can be completely disruptive in the construction industry by greatly reducing costs and construction times

Development stage

- The potential use for 3D Printing is enormous ranging from small dwellings assembled on-site to large infrastructures for commercial and personal use
- Currently, 3D Printing can be efficiently used for pre-cast modules, that need to be assembled on-site, and full printing of small buildings structures
- There are already some companies exploring 3D Printing solutions in the construction sector. Huashang Tengda, Winsun and LafargeHolcim are examples of companies that have already had successful results.

Business impact

- Less use of cement on end products final mixture due to a more efficient mix and introduction of new materials more suitable for 3D Printing
- Decrease in construction time which means faster and more efficient cement and concrete deliveries
- Need for cement and concrete mixtures that can be used efficiently on 3D Printing projects
- Cost reduction on building construction that can go up to 80%
- Relatively high investment in the printer, software development and tests, since engineers need to operate it efficiently

Environmental impact

- A 3D printer that uses a mixture of ground construction and industrial waste, such as glass and tailings, around a base of quick-drying cement mixed with a special hardening agent (feedstock made from recycled rubble, fiberglass, steel, cement and binder)
- *Use of recycled raw materials directly embedded in the printing mixture* - decrease the need for quarried stone and other materials -- resulting in a construction method that is both environmentally and cost effective.

Source: Secil/NovaSBE Team

Adoption of 3D Printing for construction (2/2)

Challenges

- While the technology has been successful in industrial applications and printing complex shapes, scale can be an issue due to the limited size of some printers and the costs associated with transportation from site to site
- Software and printer programming can be the main challenge since a simple fail can compromise an entire structure that would need to be remade from scratch
- Adopting this technology for construction in the long – term would make Secil move downstream on the value chain and compete directly with construction companies
- Currently there is not a unique universal mixture for 3D Printing. It can be challenging to have different mixtures for different printers, especially if this would not enable efficient scalable operations

Potential approach

- Take advantage of a niche market that has a huge potential for growth and benefit from research / EU funds for innovation programs
- Develop a network of compromised, reliable partners (both equipment, software and application to construction projects) in pilot tests will quickly build experience on this technology
- Initially targeted at pre-cast concrete manufacturing by replacing molds that have high costs and are specific for each project
- Major goal of early adoption is to prepare for a drastic possible shift in the construction industry

Source: Secil/NovaSBE Team

Recycle end products and components (1/2)

Initiative description

- Concrete recycling consists in reusing Construction and Demolition Waste (CDW) generated from buildings and construction that reached the end of its life
- Buildings generate many types of waste but the cement and concrete industry can only make use of a specific type of waste, namely cement derivatives, bricks and stones
- Recycled CDW can be used for concrete mixture, replacing gravel and aggregates.
- Recycled concrete can also be used for cement production replacing limestone in the burning phase. This requires waste to be separated between carbonated materials and non-carbonated materials that can be used to produce clinker

Development stage

- In Portugal, recycling of CDW is barely inexistent or residual
- In Europe, the northern countries are already recycling CDW due to the high costs and even forbiddance of landfilling

Business impact

- Direct application of circular economy by creating value from waste products and, at the same time, reducing the need for using natural resources
- The transportation logistics already exist with the delivery trucks with construction products returning empty, that now can bring CDW from the customer on the way back to the quarry
- Cost of transportation - can be soften due to reverse logistics
- Investment on infrastructure to separate and store construction and demolition waste
- Due to chemical characteristics of recycled aggregates concrete may need more cement and thus increase its cost
- Unless covered as a fee, the overall cost is likely to increase given the cheap prices of virgin aggregates from the quarry

Environmental impact

- Use of raw materials that are considered waste in other industries is a direct application of the circular economy concept. In this case it becomes even more relevant since it will not only recycle waste, minimizing disposal and landfilling, but will also decrease fossil fuel consumption and CO2 emissions in the production process

Source: Secil/NovaSBE Team

Recycle end products and components (2/2)

Challenges

- Currently in Portugal the cost of landfilling is so low that there is barely no incentive in recycling CDW
- Even if all CDW would be fully recycled, the total waste generated would only cover ~30% of the total existing concrete demand (in Portugal)
- Usage of recycled aggregates in the final product while still maintaining the product quality can be challenging due to the different characteristics of different types of waste (i.e. could require more cement in the mix or change its properties)

Potential approach

- Turn potential threat into a business opportunity by using reverse logistics for transportation of waste from construction site to quarries and the grinding capacity and space of the aggregates producers
- If the materials are well separated there should be no difference from a regular cement or concrete but this has high costs of separating and recycling waste materials when compared to using original aggregates
- The main problem with recycled concrete is its cost, that will have to either be embedded in the final product price or charged as a service to the construction companies
- The testing of the required logistics and infrastructure needed is important to be carried out by Secil, since its very likely that legislation will enforce waste recycling

Source: Secil/NovaSBE Team

Using new materials for building rehabilitation (1/2)

Initiative description

- The construction industry in developed markets whose cities lack construction space is shifting from new construction to rehabilitation and reconstruction projects
- This type of construction uses much more products such as mortars or carton-gypsum structures than traditional materials such as cement and concrete
- Rehabilitation is also seen as an investment to renovate a house or adapt it to new uses (such as renting or transfixing spaces), which requires, from the customer point of view, low cost, acceptable quality and easy and quick application

Development stage

- As an originally cement company with its own concrete production and distribution, Secil is still growing its presence in the mortar business and has to compete with larger multinationals expert in these products
- Nevertheless, Secil's product reputation will enable to benefit from a growing rehabilitation market in Portugal

Business impact

- Possibility to create value downstream with focus on specific mortars and value added concretes
- Opportunity to capture share of a increasingly growing market and to shift from company's core business (cement) to value-added products such as specific mortars and special concretes
- The transition to end product solutions and competition in retail outlets for smaller constructions can be difficult for a company that used to be focused on cement production
- Increased costs with specialized labor, new materials and more tailor-made solutions needed for these projects

Environmental impact

- By rehabilitating instead of constructing from scratch, less cement is consumed, which reduces CDW over time, its emissions, and even the consumption of natural resources
- By shifting to a more mortar-intensive industry there is also the opportunity to include more renewable materials such as glass and wood in the end-product

Source: Secil/NovaSBE Team

Using new materials for building rehabilitation (2/2)

Challenges

- Rehabilitation trend in the construction industry will take focus from large structures construction, that use more cement, to products that require different materials and are focused on a more premium and niche segment
- Shifting company vision from large concrete construction to more specific projects using various types of mortars and concretes
- This will require different, more specific marketing and commercial skills and a focus from innovation not only to develop new products that can “fill the blanks” in its product line vs competition but also to adequately test, launch, sell and train construction workers on its use

Potential approach

- Construction companies which are more focused on rehabilitating than constructing from scratch are one of the most attractive opportunities, especially if their operations are concentrated on big cities where the square meter is more expensive and there is room for a more premium offering requiring wider range of products for different end uses
- Emphasizing the reliability and added value of Secil products and solutions not just for final, specific products but for the whole service (including training and consulting the companies that use the products in its projects – this means positioning more as a consultant than a supplier to the customers
- A new approach to market and channels is required with strong loyalty programs for qualified suppliers/applicators and quality insurance service included in the products used

Source: Secil/NovaSBE Team

Alternative products to concrete and cement for construction (1/2)

Initiative description

- Using alternative raw materials can be done with two different goals and objectives:
    1. Replacing limestone in the cement formula as a substitute to reduce the environmental impact and cost of production (less clinker in the final product)
    2. Adding to the cement formula as a performance / quality enhancer to create a better, premium end-product with specific characteristics (e.g.: thermal, acoustic, elasticity, etc) by including different raw materials that can be mixed with cement to create concrete and mortars

Development stage

- Use of alternatives to clinker for cement production in Portugal is limited given the lack of raw materials such as slag or fly-ash
- In Portugal, there are already some application of performance enhanced materials and premium products, both in mortars (mainly by Saint-Goban/Weber and Sika) and also cement companies (although limited to few, special projects)

Business impact

- Take advantage of the current trend of shift from construction of new buildings towards more rehabilitation
- Opportunity to move to a premium segment of the market with the introduction of new, innovative products
- Reduce the cost of cement production due to more use of alternative, cheaper materials such as slag of fly-ash
- There may be a need for investment in infrastructures and equipment able to process some of the alternative materials
- Costs of goods sold will probably increase due to high costs of some materials (e.g: cork, metals, gems, etc) which requires a premium price

Environmental impact

- Use of raw materials that are considered waste in other industries is a direct application of the circular economy concept. In this case it becomes even more relevant because it will not only recycle waste, minimizing disposal and landfilling, but will also decrease fossil fuel consumption and CO_2 emissions in the production process

Source: Secil/NovaSBE Team

Alternative products to concrete and cement for construction (2/2)

Challenges

- Shift from company's core business (cement) to value added (although more niche) products such as different mortars and concretes with specific characteristics
- Availability and price of alternative materials can compromise the quantities needed to produce these products at an efficient scale
- Secil will compete with multinational players focused on this market needs (mortars), with broader product lines and that have already a strong know how to develop, produce, sell and advertise this type of products where quality standards are even more required

Potential approach

- Secil needs to position itself more as a building consultant (or even a "partner") and not (just) a materials supplier
- Construction companies, increasingly focused on rehabilitation, are the most attractive targets, particularly in the main cities where the square meter is more expensive and there is demand for premium products
- The use of alternative raw material in the cement production process is already optimized by Secil and dependent on materials availability
- Secil has also already tested and applied some of the new materials in niche products but the challenge is to be able to sell it as mainstream product

Source: Secil/NovaSBE Team

Evolve building construction to develop a service providing efficient house solutions (1/2)

Initiative description

- Move towards the end of the value chain trough the creation of a full integrated service aiming to deliver customers a complete construction solution instead of individual products
- Restructure the value chain in order to sell more added value products derived from cement than cement itself – need to create demand for pre-cast concrete, cement bricks and mortar instead of the cement bags sold currently to be mixed on-site
- Having more control on the selection and application of company products for each individual construction will serve both as quality warranty and also to "push" different types of products that can bring better quality to end product

Development stage

- Main European cement companies worldwide are already focusing on valuing their solution portfolio downstream
- Lafarge-Holcim is a good example of a company with a increasing presence of value-added services

Business impact

- Reduction of cement on end product
- Higher margins to capture from tailor-made services and focus on value added products
- Enhanced brand reputation trough the perceived improvement and sophistication of quality of its products
- Possibility to have more control across the whole value chain and create a distinctive service (with a warranty of quality on every step of the process)
- Operating costs will likely increase due to the need of having more in-site applicants and experts

Environmental impact

- The lower potential percentage of cement in the final mix can reduce the total impact of the industry on environment
- With a more controlled and proper application of products , the quantities of wasted materials such as water, cement and gravel can also be significantly reduced

Source: Secil/NovaSBE Team

Evolve building construction to develop a service providing efficient house solutions (2/2)

Challenges

- Internal challenge of creating a broader culture to fit the positioning of “construction solutions provider and expert” instead of “just” the cement/concrete supplier
- Long term strategic shift versus the short term profits that come from current bulk/bag concrete/cement sales
- Markets are not prepared enough to pay more for this type of offer – construction companies opt for mixing products on site and use their own labor force and expertise to apply the products with an ultimate goal to minimize cost of production given a fixed minimum quality
- Secil needs to balance its role as materials producer and solutions provider that may compete with its customers (as already exists between its cement and concrete divisions, for example)

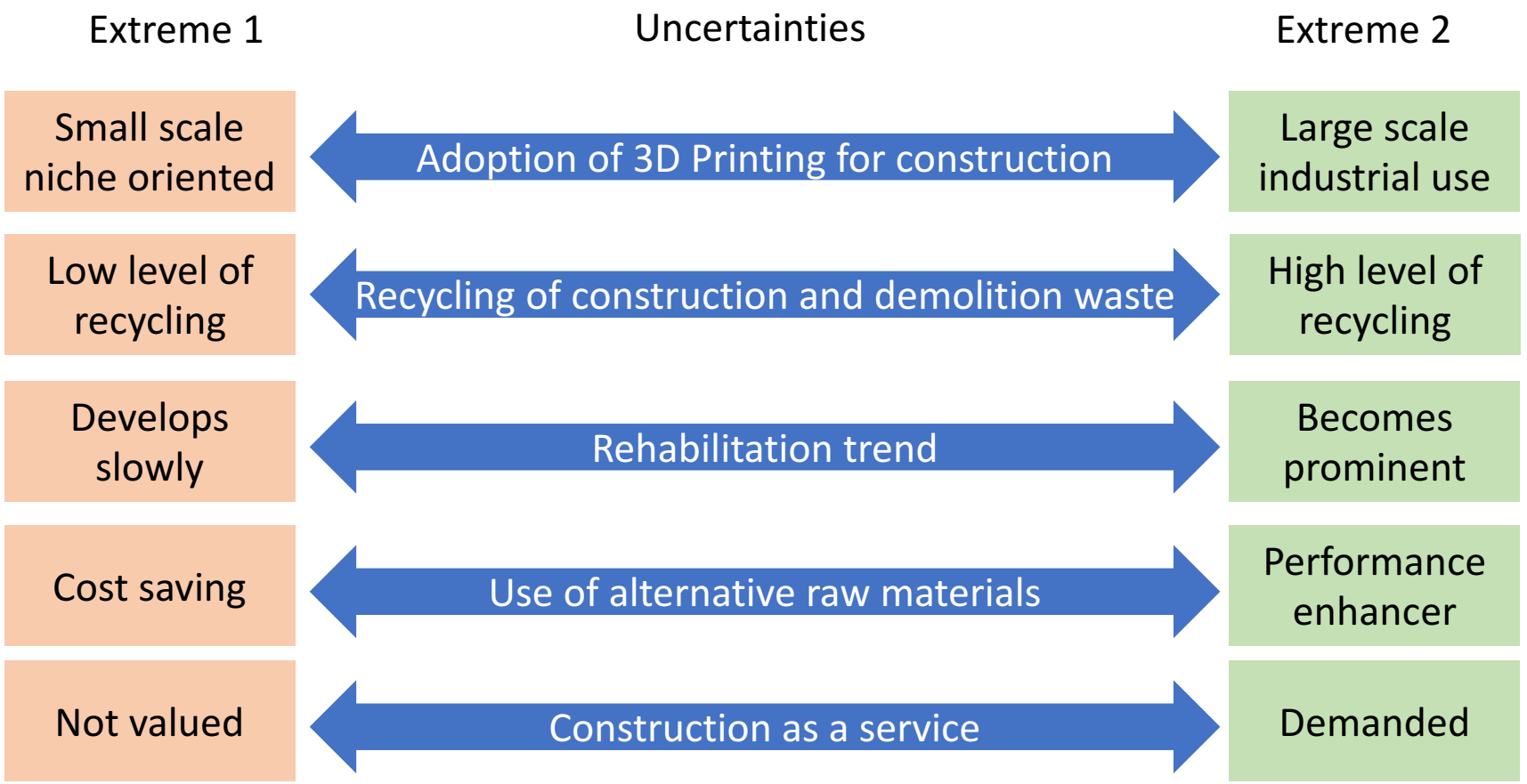
Potential approach

- Initially, larger construction companies responsible for the main public infrastructure projects are the main targets of this redefined offer that tends to be done case by case
- In the long run, Secil will need to create partnerships with construction companies and other product and service providers to be able to develop an offer with more mainstream usage, more suitable for smaller projects and less sophisticated construction companies
- Pricing will also evolve from “add-on” for each additional product device provided to a more “full-service” model

Source: Secil/NovaSBE Team

Based on the previous findings the team decided to study how could the initiatives develop in the future considering both the companies actions and the markets and industry possible evolution trends

Set of possible uncertainties directions*

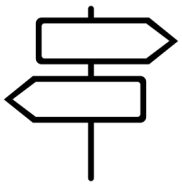


*Annex 5 shows relative impact, overall uncertainty and correlation between each uncertainty with the objective of choosing the key uncertainties for the future

Source: Secil/NovaSBE Team

After analysing and comparing all the uncertainties the team identified the two critical uncertainties that have, respectively, the major impact and the greater uncertainty attached to their development

Adoption of 3D Printing in the Construction Industry



Direction: Currently 3D Printing is used a lot in small scale projects focused on repairing and constructing furniture and decorative pieces such ornaments and statues. Nevertheless 3D Printing is already being tested and developed for large scale buildings and infrastructures, with some prototypes already on the market. The future concerning the direction of growth for 3D Printing still remains uncertain but factors such as mass production building costs and speed will be crucial in setting the direction of 3D Printing

Speed: Speed is greatly influenced by external factors such as social acceptance, technological development and regulation existent

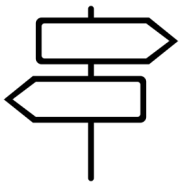
Impact: 3D Printing will surely shape the industry even if it is not adapted at a large scale and being the standard for future construction. Secil needs to develop products that are compatible with printers and, the company can even take advantage of this technology in the pre-cast concrete sector.

KPI: Number of 3D printed construction projects per country per year

Source: Secil/NovaSBE Team

After analysing and comparing all the uncertainties the team identified the two critical uncertainties that have, respectively, the major impact and the greater uncertainty attached to their development

Construction as a Service for Efficient Housing Solutions



Direction: Evolving construction to a service industry rather than just a product one is largely dependent on demand and consumer preferences. The extreme of this uncertainty would be to plan an entire projects with products and expertise from within the company and then charge periodical fees to the customer while maintaining full responsibility for maintenance and repair over the life-cycle of the building. On the other side, construction would remain as it is with contractors choosing different materials and application is done by unexperienced people undermining the quality of the end-product.

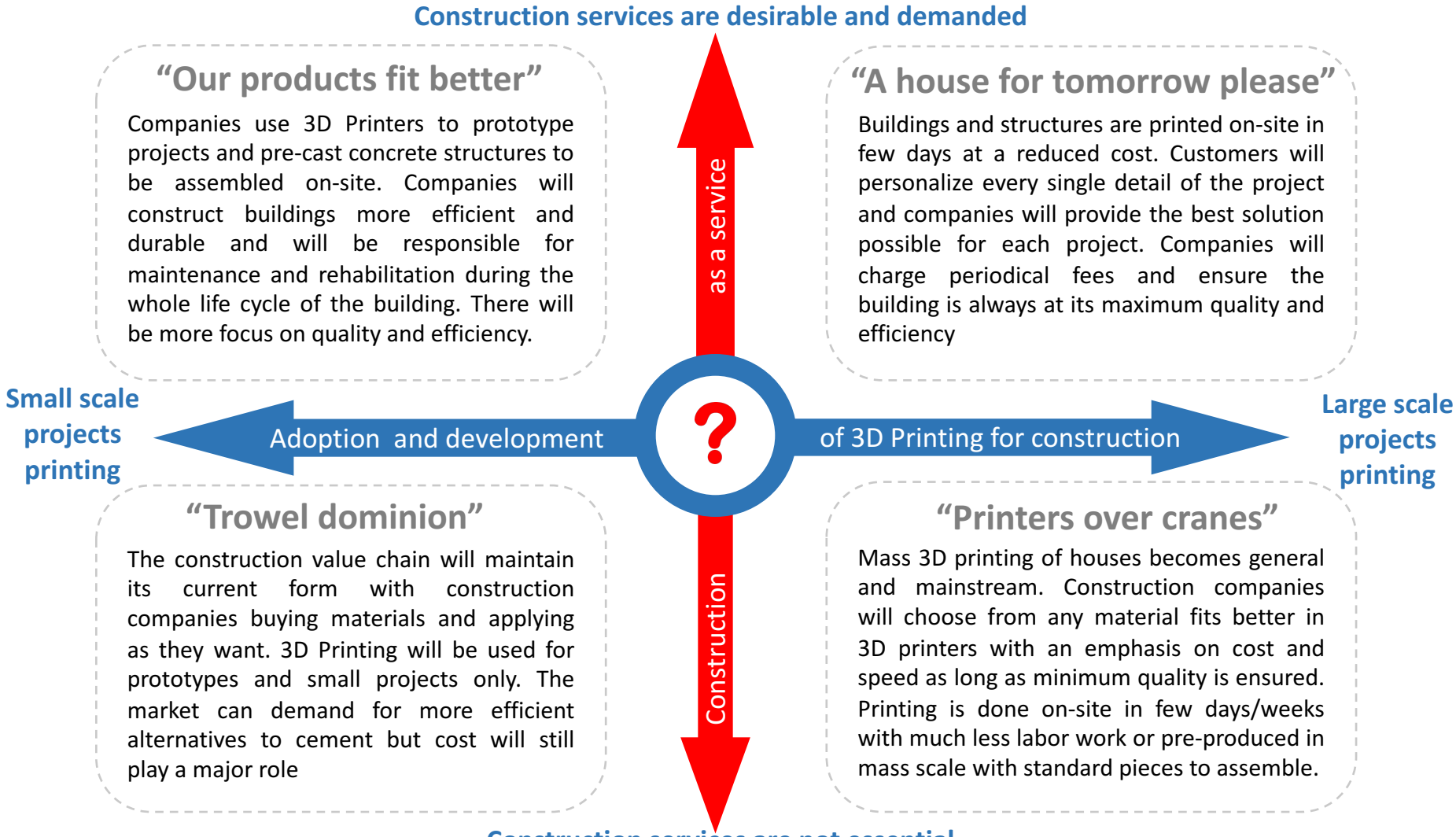
Speed: Speed is greatly influenced by the education of the consumer and the creation of demand for this type of solution.

Impact: If this type of service begins being requested by costumers Secil would have a much more downstream control of its products creating a greater emphasis on quality and longevity of the end product. The constructors, on the other hand, would leave responsibility of application and choosing of materials to the producers, which in this case, is Secil and other cement and construction materials companies.

KPI: Number of applicators per construction material company

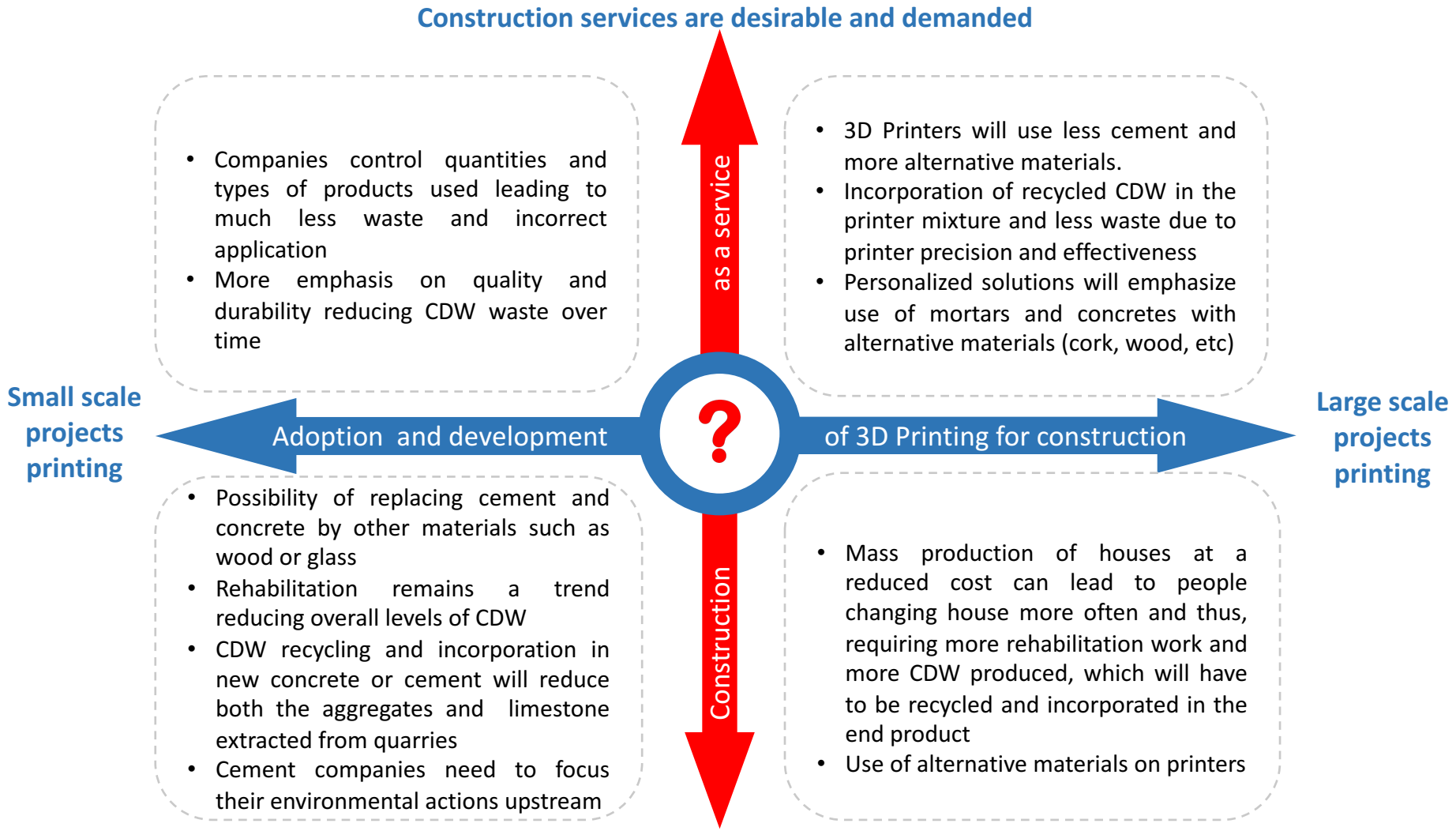
Source: Secil/NovaSBE Team

Based on the critical uncertainties and its impact the team was able to develop different scenarios having in mind how will these uncertainties be in the future



Source: Secil/NovaSBE Team

After analyzing how could the critical uncertainties develop it is important to take into account the environmental impact of each scenario



Source: Secil/NovaSBE Team

In order to prepare for the future scenarios Secil has some strategic options that can already be developed and deployed

"Our products fit better"

- Secil already has an image of specialist on concrete solutions for large, specific projects but should develop further this role and lead the market education
- This service would require a movement of focus from the upstream cement production/supply to the more downstream "cement"/solutions applications
- Partnering with architects and engineers early in the process is critical to ensure the correct use of Secil products
- This service will require a consistent high level of quality to all Secil products
- In the future, Secil would need to be able to be physically present/available in every stage of each project that involves its products, from design to post sales inspections and maintenance

"A house for tomorrow please"

- In order to capture the full value of the market and ensure the control of the process, Secil would need to not only provide the materials but also the whole solution, including the designs and constructing (printing) the houses
- This could be an issue since Secil would be competing with some of its current customers. Nevertheless if Secil is able to grab a first-mover advantage and is able to develop and deploy the necessary technology, can differentiate its offer and build experience, reputation and market share
- Ensuring the printing and the personalization of each single project, Secil would be able to have full control over quality, durability and efficiency allowing the company to charge fees for the service it would provide over the time

Source: Secil/NovaSBE Team

In order to prepare for the future scenarios Secil has some strategic options that can already be developed and deployed

"Trowel dominion"

- Secil should maintain its operating structure with an emphasis upstream in cement production but should also develop more environmental friendly alternatives in concrete and cement production, better than wood or glass to be prepared for changes in construction products demanded
- Recycling of construction and demolition waste is crucial if legislation is implemented which will require the preparation of specific infrastructure and logistics to receive and process this type of waste
- Incorporation of alternative fuels and materials in the cement and concrete production continues to be key to reduce costs and environmental impact
- A new commercial and marketing approach is critical to gaining market share in new products and stay competitive in the long term

"Printers over cranes"

- Secil should be prepared to supply products that are perfectly compatible and appropriate for 3D printers. This will particularly be relevant for developing markets that need to build large amounts of households at low cost
- The company will need to partner with reliable equipment and software/design companies and develop off-the-shelf solutions (easy to adopt for institutional customers such as schools of social houses for municipalities) and tailor-made solutions for larger projects
- The company can start testing 3D Printing in pre-cast concrete structure in order to fully optimize its mixtures and products
- Partnering with other cement companies in worldwide organizations is key to ensure that the primary material used by 3D printers is cement

Source: Secil/NovaSBE Team

Self-Assessment

Belbin Results and Key Learnings

NOVA School of Business & Economics

Shaping powerful minds

January 6, 2017

By matching Belbin results with my personality, the role that fits me the most is the Operational one, whereas the one that fits me the least is the Finisher one

Alexandra Moniz

Top roles:
Operational
Strategist
Team Work

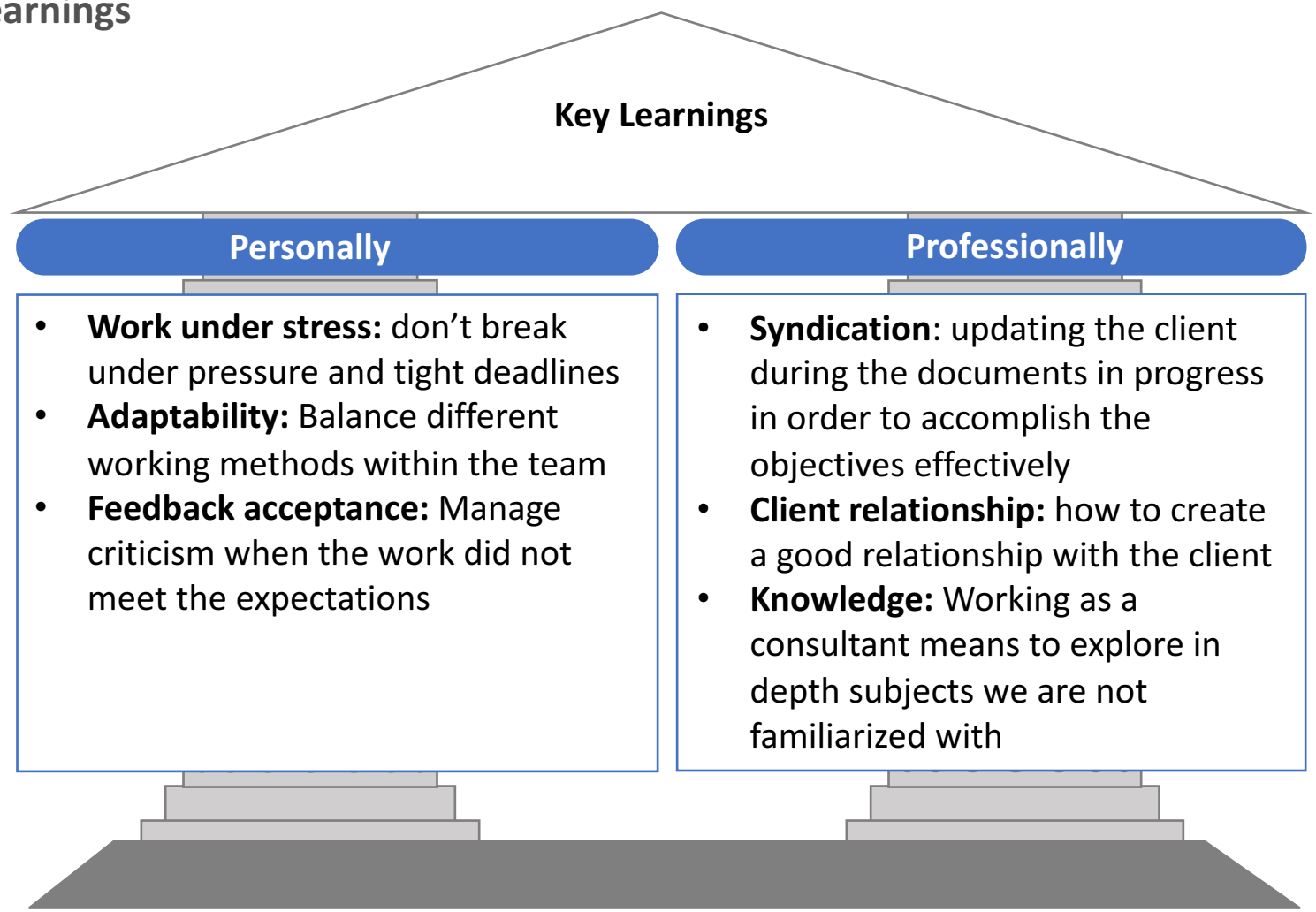
This top 3 results truly reflects my role within the team during the consulting project. I identify myself with the operational role since I prefer a hands-on approach and like to put theoretical and abstract ideas into practice. I relate myself with the strategist one as well, since I'm an extrovert person, always full of energy, outgoing and emotional. Having the team worker role as one of the top 3 doesn't surprise me, since I like to make sure that the people in the group get along and work together effectively. Being a team worker comes natural to me - I'm loyal and always aware of the individual's needs and worries.

Bottom roles:
President
Prospector
Finisher

After analyzing Belbin results on the bottom roles, I can understand why the president role does not fit in my personality. Despite being an extrovert and social person, I'm not the one always concerned about final objectives and outcomes. Besides having the prospector role as one of the bottom ones I can relate myself to it since I get easily demotivated and bored if the work involved is stagnated or without the stimulus of others.
Considering the bottom role, the finisher is the role that least describes my character within the team. The person within the role usually is introvert and nervous, always worrying in what can go wrong. Even though it's critical to have quality checks and revisions on the project, the eye for detail and precision doesn't come natural to me.

By learning about myself and my capabilities, this project made me grow in an individual and professional manner

Key Learnings



By matching Belbin results with my personality, the role that fits me the most is the Monitor one, whereas the one that fits me the least is the Team worker one

Miguel Fontoura

Top roles:
Monitor
Prospector
Finisher

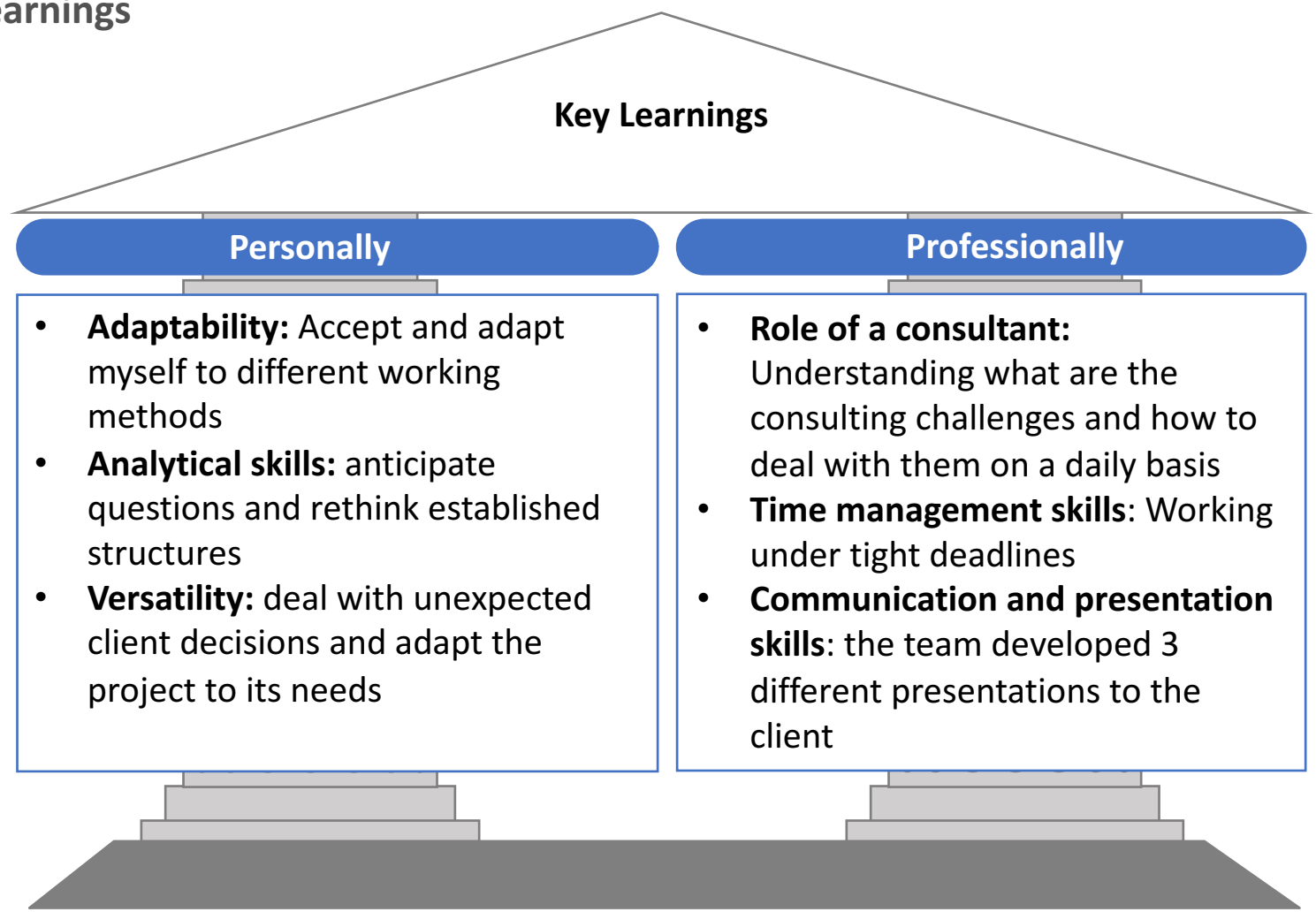
After analyzing Belbin's results, I can conclude they were very accurate, since I'm a really objective person and have a serious approach. I only criticize the team's work when I see a flaw in the project, or something that can be improved. I identify myself as a prospector due to my ability to stimulate new ideas and innovative approaches within the group. The role that I relate the most is the finisher one, since I consider myself a perfectionist always concerned with the small details and making sure everything is done on time and with quality.

Bottom roles:
President
Strategist
Team worker

In what concerns the bottom roles, I identify myself much more as a leader in the work itself rather than within the team, reason why the president role is not the one that most fits my personality. Nevertheless, I see myself as a goal-focused person despite creativity not being my strong point. The strategist role does not fit well in my behavior due to the fact that I am completely focused and objective on the work and what needs to be done, instead of worrying with the other team members' performance. This also leads to a poor result on team worker role because, even though, I have good social and communication skills, I am not sensitive and emotional enough.

By learning about myself and my capabilities, this project made me grow in an individual and professional manner

Key Learnings



By matching Belbin results with my personality, the role that fits me the most is the President one, whereas the one that fits me the least is the Intellectual one

Pedro Pinto Gomes

Top roles:
President
Team Worker
Monitor

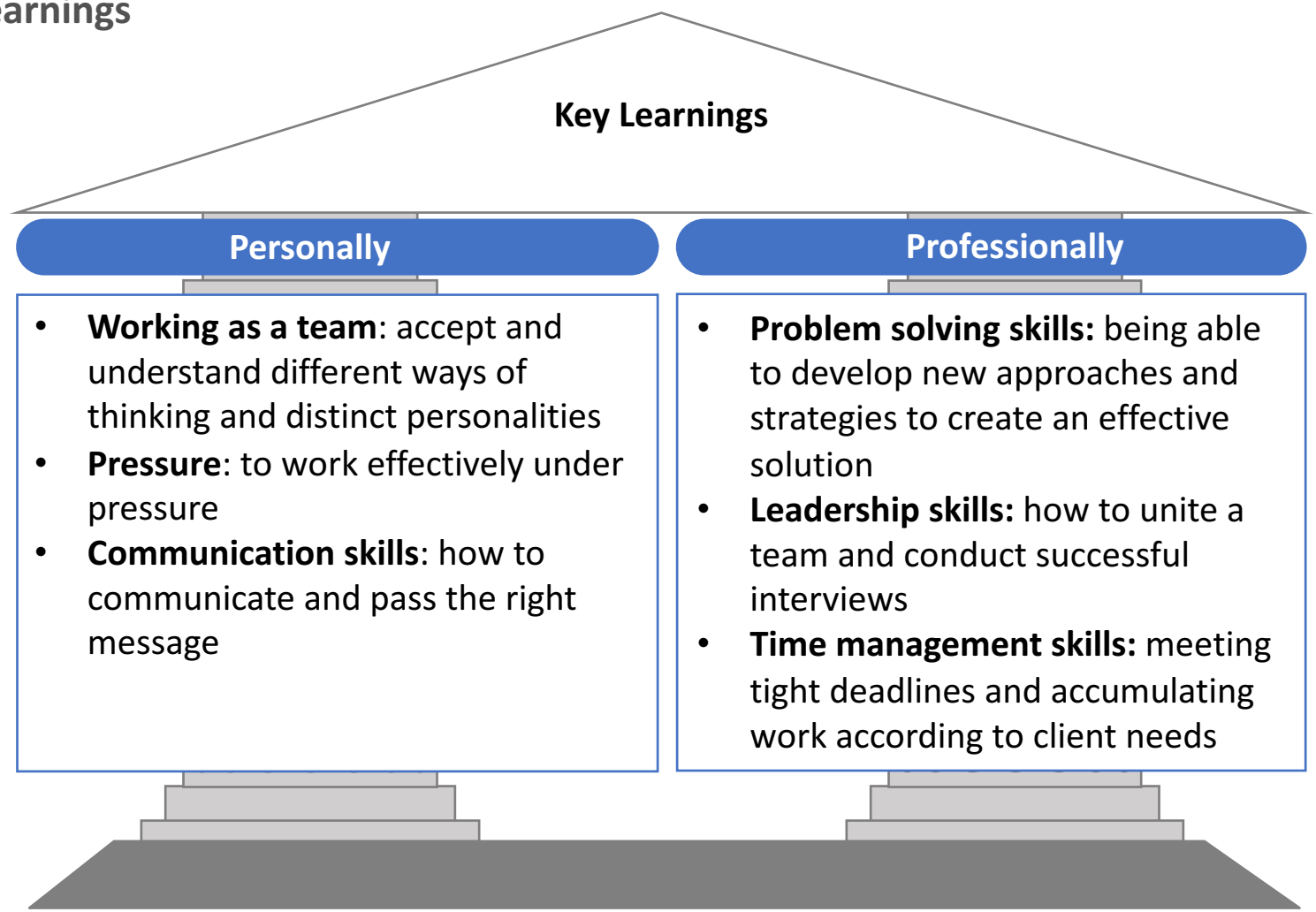
During this project, and after analyzing my role in the team, I was able to relate with the Belbin results findings. I was able to identify myself with the President role since I believe I'm an extrovert and stable person and possess leadership skills within the team. I was able to have a dominant role over the project but always in a relaxed and unassertive way. The role of a team worker is probably the one that I could more easily relate since I was able to involve every team member in every single decision and motivate the members in different occasions. The monitor role has also some characteristics that fit my personality and behavior within the group. My critic approach to every problem was important to define clear goals and objectives, as well as analyze different problems and situations.

Bottom roles:
Prospector
Finisher
Intellectual

The Belbin analysis also made me understand what are the roles that are unrelated with my personality and that I needed to work on them during the project. Despite working well under pressure and improvising well, I lacked in social skills to create empathy with some of the company collaborators. The finisher role is the one that I least identify myself with, since I am not a perfectionist person that pays too much attention to details. The intellectual is clearly not my best role since I am much more practical and goal-oriented than creative or analytical.

By learning about myself and my capabilities, this project made me grow in an individual and professional manner

Key Learnings



References

NOVA School of Business & Economics

Shaping powerful minds

January 6, 2017

HSBC, (2012). Construction and building materials. Available at: http://www.hsbcnet.com/nutshell/attachments/pdf/latinAmerica-construction-and-building-materials.pdf

Ellen MacArthur Foundation, (2016). The Circular Economy and the promise of glass in concrete. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/case-study-the-promise-of-glass-in-concrete.pdf

Cembureau (2016). Available at: http://www.cembureau.be/about-cement/key-facts-figures

Cembureau (2016). Available at: http://www.cembureau.eu/about-cement/cement-industry-main-characteristics

Secil-Group (2016). Available at: http://www.secil-group.com/a-secil/?lang=en

INE, (2014). Construction and habitation statistics. Available at: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpub_boui=224786561&PUBLICACOESmodo=2

Global Cement Magazine, (2015). Available at: http://www.globalcement.com/magazine/articles/964-preview-the-top-100-global-cement-companies-and-global-per-capita-capacity-trends

European Commission, (2016). Available at: http://ec.europa.eu/europe2020/targets/eu-targets/index_en.htm

Eurostat, (2016). Available at: http://ec.europa.eu/eurostat/web/europe-2020-indicators/europe-2020-strategy/main-tables

Eurostat, (2016). Available at: http://ec.europa.eu/eurostat/web/europe-2020-indicators/europe-2020-strategy/main-tables

European Commission, (2011). DG ENV (2011) Final Report Task 2 – Management of C&D Waste. Available at: http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf

United Nations, (2015). Time for Global Action for People and Planet. Available at: http://www.un.org/sustainabledevelopment/wp-content/uploads/2015/08/Factsheet_Summit.pdf

Financial Times, (2015). Let this be the year when we put a proper price on carbon. Available at: https://www.ft.com/content/10cb1a60-9277-11e4-a1fd-00144feabdc0#axzz3OcrWTCnt

Carbon Tax Center, (2016). Available at: https://www.carbontax.org/contact-us/best-articles

The Washington Post, (2015). Oil's swoon creates the opening for a carbon tax. Available at: https://www.washingtonpost.com/opinions/oils-swoon-creates-the-opening-for-a-carbon-tax/2015/01/04/3db11a3a-928a-11e4-ba53-a477d66580ed_story.html?utm_term=.91bdb2bfa53d

Carbon Tax Center, (2016). Available at: https://www.carbontax.org/whats-a-carbon-tax/

European Commission, (2016). Available at: http://ec.europa.eu/clima/policies/ets_en

Ecofys, (2016). Impacts of a Global Carbon price on Consumption and Value Creation. Available at: http://www.ecofys.com/files/files/carbon-pricing-unlocked-2016-impact-on-value-creation.pdf

WBCSD, (2016). Available at: http://www.wbcsdcement.org/index.php/key-issues/sustainability-with-concrete/properties-of-concrete

Canadian Wood Council, (2003). Energy and the Environment in Residential Construction. Available at: http://cwc.ca/wp-content/uploads/publications-Energy-and-the-Environment.pdf

Ellen MacArthur Foundation, (2013). Towards the Circular Economy: Economic and Business Rationale for an accelerated transition. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf

European Commission, (2015). Circular Economy Package – What's in it?. Available at: http://ec.europa.eu/environment/circular-economy/pdf/seminar/1%20DG%20ENV_Circular%20Economy%20package.pdf ,

United Nations, (2015). Available at: http://www.un.org/en/development/desa/news/population/2015-report.html

OECD, (2012). An Emerging Middle Class. Available at: http://oecdobserver.org/news/fullstory.php/aid/3681/An_emerging_middle_class.html

United Nations Environment Programme, (2011). Available at: http://www.unep.org/resourcepanel/publications/decoupling/tabid/56048/default.aspx,

World Bank, (2013). Available at: http://www.worldbank.org/en/news/feature/2013/10/30/global-waste-on-pace-to-triple

European Commission, (2015). Closing the loop – An EU Action Plan for the Circular Economy. Available at: http://projects.sigma-orionis.com/flagship/wp-content/uploads/2015/12/FLAGSHIP_Circular-Economy-Werner-Bosmans.pdf

Ellen MacArthur Foundation, (2015). Towards a Circular Economy: Business Rationale for an Accelerated Transition. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/TCE_Ellen-MacArthur-Foundation_9-Dec-2015.pdf

Ellen MacArthur Foundation, (2015). Growth Within: A Circular Economy Vision for a Competitive Europe". Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Growth-Within_July15.pdf

Ellen MacArthur Foundation, (2016). Intelligent Assets Unlocking the Circular Economy Potential. Available at: at: https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthurFoundation_Intelligent_Assets_080216.pdf

CSI, (2009). Recycling Concrete. Available at: http://www.wbcsdcement.org/pdf/CSI-RecyclingConcrete-Summary.pdf

3D Printing Industry, (2016). Available at: https://3dprintingindustry.com/news/3d-printing-technique-currently-challenging-global-construction-industry-77432/

3D Printing Industry, (2016). Available at: https://3dprintingindustry.com/news/how-viable-is-3d-printing-for-building-large-structures-75032/

3D Printing Industry, (2016). Available at: https://3dprintingindustry.com/news/top-10-3d-printed-construction-innovations-83578/

CNET, (2016). Available at: https://www.cnet.com/news/worlds-first-3d-printed-apartment-building-constructed-in-china/

CNET, (2016). Available at: https://www.cnet.com/news/dubai-unveils-worlds-first-3d-printed-office-building/

LafargeHolcim, (2016). Available at: http://www.lafargeholcim.com/sites/lafargeholcim.com/files/atoms/files/09202016-press-lafargeholcim_innovates_3d_concrete_printing-en.pdf

Cembureau, (2013). Available at: http://lowcarboneconomy.cembureau.eu/index.php?page=alternate-fuels

Holcim, (2016). Available at: http://www.holcim.com/media-relations/our-major-projects/holcim-in-partnership-with-leading-swiss-research-institutes-paul-scherrer-institute-and-eth-zurich.html

Paul Scherrer Institute, (2016). Available at: https://www.psi.ch/media/the-sun-rises-for-cement

Cembureau, (2013). Available at: http://lowcarboneconomy.cembureau.eu/index.php?page=clinker-substitution

Portland Cement Association, (2016). Available at: http://www.cement.org/docs/default-source/newsroom-pdfs/resiliant-d2.pdf?sfvrsn=2

Novacem, (2010). Novacem: Carbon Negative Cement and the Green Cement Bond. Available at: http://www.wbcsdcement.org/pdf/CSIForum2010/05%20Novacem%20at%20CSI%20Forum.14%20Sept%202010.for%20distribution.pdf

WBCSD, (2016). EEB Amplify Energy Efficiency in Buildings 2017-2020. Available at: http://www.wbcsd.org/Projects/Energy-Efficiency-in-Buildings/Resources/EEB-Amplify-2017-2020

Carbon Capture and Storage Association, (2016). Available at: http://www.ccsassociation.org/what-is-ccs/

Secil-Group, (2016). Available at: http://www.secil-group.com/2016/10/28/inauguration-of-microalgae-production-unit/?lang=en

Carbon Capture and Storage Association, (2016). Available at: http://www.ccsassociation.org/faqs/ccs-globally

Joule Unlimited, (2015). Available at: http://www.jouleunlimited.com/about-joule